THE *Petroleum* Engineer — Management Edition

Exploration—Drilling—Producing • Refining—Petrochemicals—Gas Processing • Oil and Gas Pipelining

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XUM

Depletion Allowance — Victim of Its Own Success

THE depletion allowance is a continual political question brought up repeatedly in the 28 years it has been in force.

Prime reason for extraordinary attention to the depletion allowance for the oil industry is its political appeal to candidates in states that have consumers but no producers of oil. To them this tax allowance is a "loophole" where one industry receives undeserved tax consideration. The coal industry, with its 15 per cent depletion allowance, is seldom mentioned. When it is, it is coupled with the idea that the petroleum industry should have only as much allowance as coal, although coal is much less difficult and less expensive to find.

The depletion allowance suffers from the difficulty of explaining its application and its effect to those outside the tax division of the petroleum industry.

The provision applies only to actual output of a producing oil well. There is no such thing as depletion allowance on dry holes. When an operator drills a successful well and produces it, he pays on 72½ per cent of the production. The purpose is to permit the operator enough profit so that he can find new reserves to restock his depleting store of oil. This can be compared broadly to taxing a merchant for only part of the cost of the goods he sells. The oil sold by the operator cannot be ordered by telephone or letter. He must go out and, at an average cost of nearly one million dollars, find deposits, which he hopes are large enough to replace those he is now marketing. The bill might more appropriately be named "restocking provision."

The depletion allowance has brought criticism from well-meaning persons, such as Senator Williams of Delaware, who cannot see that our abundance of oil is due in large part to the provision. The allowance receives consistent condemnation from left-wing elements. The long range objective of many of the latter is nationalization of natural resources. Because it has played a vital part in providing ample oil supplies of petroleum, the depletion allowance is the first large hurdle on the road to limited supplies, which is always a strong argument for the federal government to take over.

Since the 1926 decision to forego taxes on 27½ per cent of oil production, there have been no shortages of oil supplies to United States consumers, except during active conflict when all vital materials were rationed and except for spot shortages brought about by inequitable price controls.

Now let us take a look at the possible and probable results of no depletion allowance or a reduction of the present 27½ per cent.

A reduction would take more time to be felt but would still have the same effect eventually. With rising costs of finding oil, the amount of the depletion allowance should logically rise instead of being cut back.

For the consumer there would be little immediate change. The margin of between one and two million barrels a day of oil production, which has been built up for emergencies of blockade and war, would serve as a cushion for fulfilling demand. Activity in the petroleum industry, however, would slow up overnight. Experienced operators would produce and sell the reserves they had developed but a good percentage would decline to take the gamble at high expense to find new stocks.

Activity would slow up in the equipment and machinery industry that sells to the petroleum industry; in the vast service industry, such as well cementing, logging, and perforating, etc., and in the basic industries, such as steel, that sell to the supply and service companies.

It would mean permanent lay-offs for thousands of workers in the petroleum industry and in its countless associated industries.

The first consumer-felt effect would inevitably be higher prices, not only for oil products but for practically everything the consumer buys. No cost is more built-in the U. S. economy than petroleum, which supplies about 62 to 64 per cent of the mechanical energy of the nation. It has gained that position of chief energy supplier because of the fact that it was available in abundance at low cost. It would be difficult to name one product a consumer buys that is not dependent on oil or gas somewhere along the line of its production.

First political dilemma, however, to grow out of a depletion allowance cut, would be the imports problem. Imported oil has no depletion allowance in this country, of course. Imports would be in a position virtually to push domestic production to the wall in peace or cold war periods but would leave the nation destitute of oil in case of an emergency of general war or even of strategic small wars.

Congress would have no choice but to contrive some protection for the domestic industry and the cost of this type of protection would undoubtedly be more than the elementary tax justice embodied in the depletion allowance.

The depletion allowance was a wise move in 1926 and year after year the different sessions of Congress have agreed, against short-sighted opposition, that it is equitable in the unique petroleum industry. While removal would be hard on the oil industry, it would be even more disastrous to the U. S. economy and endanger the safety of the nation.

Ernestine Adams.

SERVICE

that is saving dollars...

IN RECONDITIONING customer's pumps at "Oilwell's" Odessa, Texas, pump shop, old balls and seats are carefully checked for accuracy of mating under vacuum.

COMPLETELY NEW "Oilwell" pumps are custom assembled to meet the requirements of individual wells. Similar assembly practices are followed in reconditioning customer's pumps, regardless of make.

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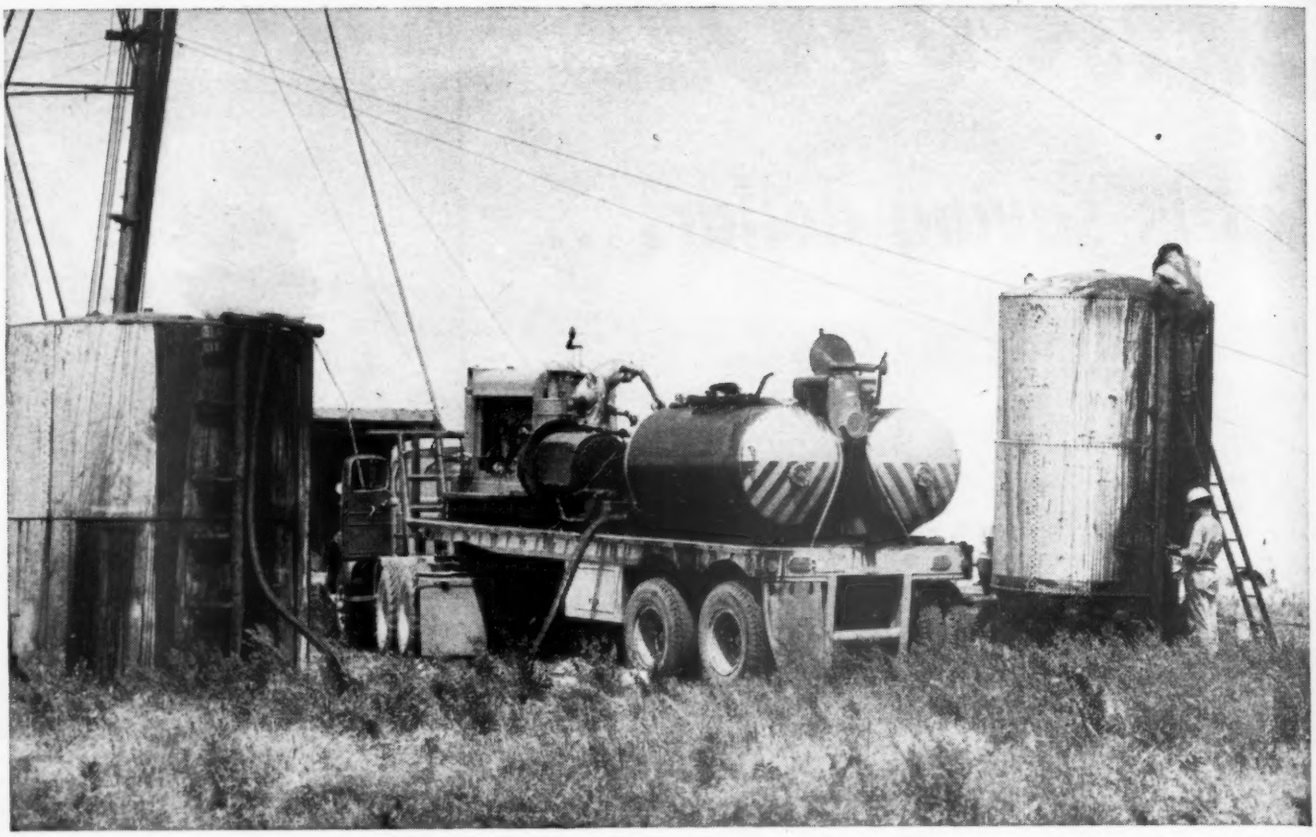


STRATAFRAC

EXCLUSIVE DOWELL SERVICE COMBINES

Case histories show production increases from wells completed in many kinds of formations

Stratafrac* is an exclusive Dowell service that fractures and acidizes formations in one operation. It is designed to extend existing fractures and create new ones.

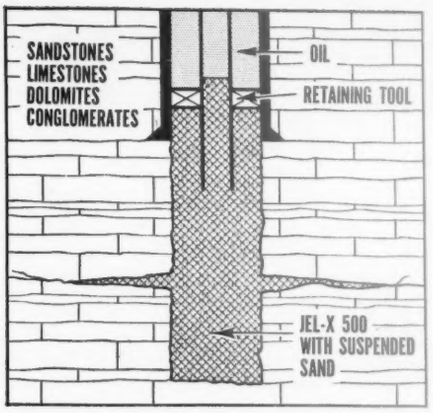
These case histories are a few examples from thousands of jobs where Stratafrac treatments increased production. A well completed in a sand formation jumped from 48 to 624 BOPD. Production from a well in a chat was increased from 1 to 264 BOPD. Production was raised from a show to 210 BOPD from a dolomite pay. And a gas well went from 4,000 MCF to 53,500 MCF.

Stratafrac has proved to be an efficient method of increasing production from sandstone, chat, conglomerate, limestone and dolomite formations not adaptable to conventional acidizing.

In Stratafrac treatments, a mixture of sand and Jel X 500 (a vis-

DOWELL SERVICE

Especially designed Dowell trucks are used to transport the sand-carrying gel used in Stratafrac treatments. The heavy-duty pumps are designed for high-pressure, high-volume injection. Such equipment has helped Dowell engineers perform thousands of fracturing treatments with profitable results for oil operators.



Specify Stratafrac—to dissolve soluble materials in formations . . . to enlarge old fractures and open new ones . . . to carry sand into fractures as an abrading agent.

Stratafrac requires no work-over rig. High-pressure lines are hooked directly from pump truck into tubing at well head by experienced Dowell engineers.

ACIDIZING AND FRACTURING

cous, acid-kerosene gel) is pumped into producing formations to create lenses of artificial permeability. The acid concentration and the size and amount of sand employed in Stratafrac can be varied to fit formation characteristics. A recent trend in fracturing has been the development of batch treatments—a fine grain sand followed by a coarse grain sand.** Dowell's complete control of all phases of this operation assists in the creation of larger ultimate fractures, giving better fluid drainage.

For complete information on Stratafrac, and the many other Dowell services developed for the oil industry—such as Acidizing, Perfojet, and the Electric Pilot—contact your local Dowell Station. Or, if you prefer, write directly to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. F-12.

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This is Jel X 500, used in Stratafrac. This viscous fluid holds sand in suspension, in ratios up to 7 lbs. per gallon, predetermined to meet formation characteristics. No gel-breaker solution is required.

—chemical service for the oil industry

DOWELL

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Urges Economics Be Taught

Management must teach economics to employees and the public alike "as a matter of self-preservation," Limuel R. Boulware, vice president of General Electric, told the oil industry in a recent speech. Boulware also said that without sound widespread economic education there could not be good employee or community relations for business or the professions.

★ ★ ★

Magnolia Scholarship

Southern Methodist University has been selected by Magnolia Petroleum Company as a recipient for a scholarship for the 1954-55 school year. The scholarship will be sponsored by the company's geological department and is in line with the policy to encourage and assist outstanding students in petroleum fields. SMU is participating in the program for the first time.

★ ★ ★

Possible Price Rise

Saudi Arabia and Iraq are seeking more money for the oil their countries are producing. They are reportedly asking for an increase in the base price on which their 50-50 sharing arrangement is calculated. It is believed that a 30 to 50-cent a barrel boost in the base price is being asked.

Syria, Lebanon, and Jordan are also asking more money for right-of-way for pipelines that cross their lands. Part of Saudi Arabia's and Iraq's oil move through pipelines to the Mediterranean. Ibn Saud, Saudi Arabia ruler, is reported to have entered into an agreement with Aristotle Onassis, whereby Onassis' tankers would eventually have exclusive rights to move all of Saudi Arabia's oil.

★ ★ ★

Russian Oil

Russia is reported to have entered into commitments for about 25,515,000 bbl of crude and products, mostly to Finland, France, and Argentina. This was stated by the Foreign Operations Administration in a report to congress. A warning to nations of the free world not to become dependent on Russian oil was sounded in the report. FOA said if the Russians should decide to withdraw from the world market, as they did in the 30's, those countries whose production has been stimulated by entrance of Russia into the market, will be the losers.

Protest Gas Import Limit

Proposed legislation to limit the importation of natural gas from Canada or Mexico is under fire from a group of Western gas companies. The companies told a Senate commerce subcommittee the bill would injure economic development of the West and for all practical purposes would ban gas importation from Western Canadian fields.

Sponsors of the bill argue that import or export of natural gas would not be in the public interest in instances where FPC finds such exportation or importation "will result in economic dislocation, unemployment, or injury to competing fuel industries of the U. S."

★ ★ ★

Oil Equipment Survey

Members of the PESA have been asked what the petroleum equipment industry can accomplish in an emergency attack by a foreign power. The survey being made will cover sources of raw materials used in making oil tools, percentage of productive capacity given to such output, utilization of substitute materials, and the potential of the industry in case of a bottleneck.

★ ★ ★

Foreign Oil Tariff Cited

Senator George W. Malone of Nevada, chairman of a senate subcommittee on minerals and fuels, advocates a protective tariff for the oil industry. He is in favor of a flexible tariff based on the difference between production costs of this country and that of competing nations. The Senator would achieve his purpose by letting the present Trade Agreement Act expire. Unless extended by pending legislation the act expires June 15.

★ ★ ★

Canadian Oil Markets

Markets for Canadian oil reserves may be found at the expense of older areas in the Mid-Continent and other fields. Studies of Canadian production by a major oil firm forecast that production will average 260,000 bbl a day in 1954. This is considerably below the estimated maximum efficient production.

Markets in the U. S. that may eventually be supplied by Canadian crude are the Central Michigan area, Detroit-Toledo area, and the Chicago region. These three sections have a refining capacity of 864,000 bbl a day. Should Trans-Mountain enlarge its system from Edmonton to Vancouver to 300,000 bbl a day, Northwestern U. S. plants could possibly be supplied with crude from Western Canada.

★ ★ ★

Texas Gas Shortage?

Some Texas areas may be hard pressed for natural gas supplies in 12 years, says former Texas State Senator C. S. Small, Sr. The problem is not that Texas is running out of gas but that the bulk of the gas produced is being delivered to other states. Latest reports of the Railroad Commission showed Texas exported 205,698,611,000 cu ft of gas in February of this year. That represented 43 per cent of all gas produced in Texas and nearly 70 per cent of gas that went into transmission lines.

★ ★ ★

Recovery Research Fund

Funds for continuing research work at Wichita Falls on secondary recovery of oil from stripper wells has been asked of a Senate Interior appropriations sub-committee. S. Leslie King, speaking before the committee for the North Texas Oil and Gas Association, said the money spent on such research has paid big dividends. He said methods already developed should result in production of an additional 80,000,000 bbl from the KMA field and 30,000,000 bbl from Burkburnett field.

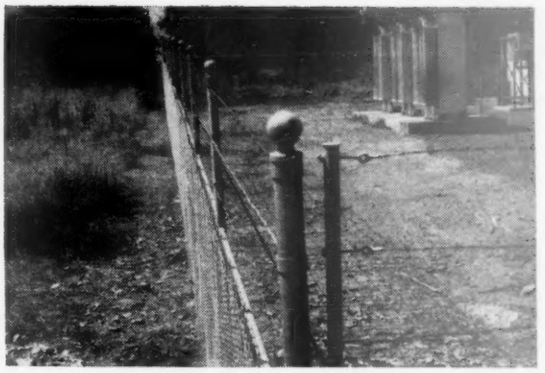
★ ★ ★

Texas Output Increases

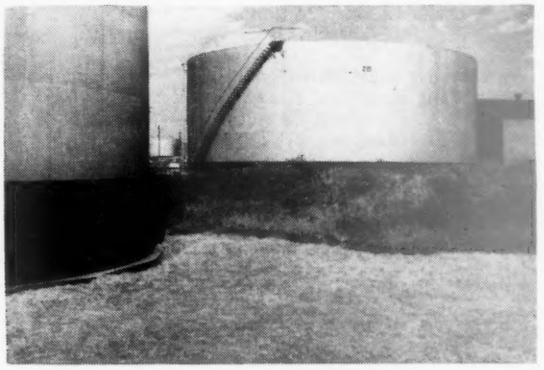
An increase of 70,024 bbl per day in the June allowable has been ordered by the Texas Railroad Commission. The increase raised the daily flow to 3,010,515 bbl. Chairman Thompson said the commission felt the raise was justified partly because of the cut that was made in the May allowable.

A majority of the major oil purchasers had requested the increase. Purchasers against the hike, said that business is slowing down and forecasts for demand of crude oil and its products are not promising. The Bureau of Mines, however has estimated a demand for 2,810,000 bbl per day in June, a raise of 10,000 bbl from its May estimate. Louisiana's oil allowable has been cut three per cent for June. John L. Hussey, conservation commissioner, said that the cut would be in the "depth bracket," roughly making allowables proportional to well depths. Louisiana has cut its per-well allowables by 30 per cent since March 1953.

1. "Telvar" W has extra-long residual action. Track on right was treated in April; photograph was taken in August. Ideal for sidings, around loading docks, etc.



2. Note the thorough weed control under and around this security fence and power substation.



3. Fire hazards are reduced around oil storages and pipelines from thorough, long-term weed control with "Telvar" W.

Kill weeds with Du Pont "Telvar" W *Weed Killer* —long residual action lasts all season

HERE'S a new, low-cost way to solve your weed control problems. Just one application of "Telvar" W can get rid of unwanted vegetation for a full growing season or longer. This powerful weed killer works through the roots . . . and remains in the ground to prevent regrowth. "Telvar" W keeps storage and working areas clear, neat and accessible . . . kills vegetation that may cause a fire hazard or a cover for vermin.

SAVES MONEY, TIME AND WORK . . . One spray usually does the job . . . repeat applications are seldom necessary. No bulky chemicals to handle or store. Just 1 to 1½ pounds per 1000 square feet (40 to 60 pounds per acre) will do the job.

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EASY TO USE . . . "Telvar" W is a wettable powder, ready to mix with water; can be applied by machine equipment or ordinary knapsack sprayer. It doesn't corrode metals, is non-flammable, has unusually low toxicity and it is non-volatile.

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On all chemicals always follow directions for application. Where warning or caution statements on the use of the product are given, read them carefully.

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☐ Please send me your booklet describing low-cost weed control with "Telvar" W. ☐ Send me the name of my nearest supplier. ☐ Give me the name of a near-by custom sprayer.

Name_____

Firm_____

Position_____

Address_____

City_____

XUM

New Oil Board Named

Secretary McKay has appointed 21 oilmen to a new Military Petroleum Advisory Board. It will advise the Defense and Interior departments on petroleum matters affecting national security and defense. The first such board was established in 1946 but was inactive during the Korean conflict.

Board members named for terms ranging from one to three years are:

Elmer Brazell, Washington; Reid Brazell, Leonard Refineries; C. E. Davis, Shell; D. K. Ludwig, National Bulk Carriers; B. L. Majewski, Great American; A. C. Rubel, Union of California; J. E. Warren, National City Bank of New York; Paul Benedum, Hiawatha Oil and Gas; G. A. Davidson, Standard of California; M. S. Jameson, IPAA; J. H. Marshall, Signal Oil and Gas; C. S. Snodgrass, Washington; C. E. Spahr, Standard of Ohio; C. E. Webber, Sun Oil; S. P. Coleman, Jersey Standard; J. T. Duce, Arabian American; J. W. Foley, The Texas Company; W. M. Holaday, Socony-Vacuum; W. W. Keeler, Phillips; G. L. Mateer, Cities Service, and R. E. Nelson, Standard of Indiana.

★ ★ ★

Plan Union Ratification

The OWIU has called a special convention to ratify entry of the union into the new Oil and Chemical Workers International Union. The new union was founded in February by a Philadelphia convention of oil workers. The OWIU is the only union as yet to call a ratification convention.

★ ★ ★

Propose Wage Increase

O. A. Knight, president of the Oil Workers International Union, has recommended a union drive for a wage increase. He says that "oil companies are making more profits than they were the last time wages were adjusted. But they are doing this with a working force that is getting smaller all the time." Knight will take his recommendation before the union's policy committee in June.

According to annual reports of 70 oil companies employment continues at a record high.

★ ★ ★

Urges Political Activity

West Coast oil men are urged by Raymond Moley, Columbia university law professor and newspaper columnist, to be more active in politics. Moley, speaking before the API, said that political activity will not hurt a business but inactivity may result in not having any business to hurt.

PAD Officially Dead

PAD, the Petroleum Administration for Defense, was abolished April 30 by Secretary of Interior McKay. Its remaining functions were transferred to the Department of Interior's Oil and Gas Division. PAD was established after the outbreak of the Korean war. Its functions included mobilization of the oil and gas industries to meet increased demands resulting from the defense emergency.

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Exchange Oil Students

The Southern Regional Education Board has formed a special petroleum sciences committee. The Board promotes interstate exchange of students in specialized fields of professional education who have less adequate educational facilities in their respective states.

★ ★ ★

Gas Sulfur Taxable

The Texas Court of Civil Appeals decreed that sulfur extracted from petroleum must pay the same tax as that of sulfur produced by other methods. The test case involved payments by Phillips Chemical Company. Phillips has been extracting commercial sulfur from sour natural gas for two years.

A lower court held that the process was chemical and the tax on "production" did not apply, but Associate Justice R. G. Hughes of the Appeals Court disagreed. He said the only question was whether Phillips "produced" sulfur from petroleum.

★ ★ ★

Japan Wants Iranian Oil

Haruo Tejima, director of Idemitsu Kosan Company, is reportedly negotiating for purchase of 200,000 tons of Iranian oil. Idemitsu Kosan recently won a court case concerning an early purchase of Iranian oil. The court case was filed by Anglo-Iranian Oil Company in an effort to block Japanese import of oil from Iran.

★ ★ ★

Offshore Leasing Rules

Rules for obtaining leases from the Federal government on submerged lands beyond the Continental Shelf are released. Major points in the regulations were: Provision for competitive leasing of all outer Continental Shelf lands on royalty and rental terms to be stated in the notice of lease offer; issuance of sulfur leases for 10 years, and so long thereafter as there is production or plant construction or other operations aimed at production; applicants for leases must be United States citizens, associations, or corporations. The oil and gas supervisor of the U. S. Geological Survey will have authority to approve drilling and development plans, to hold hearings, and to determine and collect rental and royalties.

★ ★ ★

Exploration Invited

Turkey has issued a decree listing regions opens to activities of foreign oil companies. The Turkey-Soviet frontier areas are not listed but foreign firms will be permitted to operate in southeastern Turkey, where most of the richest oil fields are believed to be.

A government-controlled petroleum company was also formed to operate the two existing fields in Turkey and to continue exploration on behalf of the government. It will have equal basis with private interests in exploration concessions.

★ ★ ★

Oil Import Curb Asked

The Independent Petroleum Association of America has passed a resolution asking that legislation be enacted to halt foreign oil importation. Based upon a six-months survey the IPAA said voluntary reduction has failed to lessen imports; domestic output is being supplanted in U. S. markets; shut-in-production has been effected; the economy of oil producing states is being threatened and principles of equity have been violated by not cutting imports in proportion to domestic reductions.

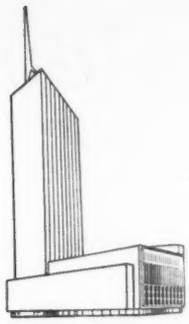
★ ★ ★

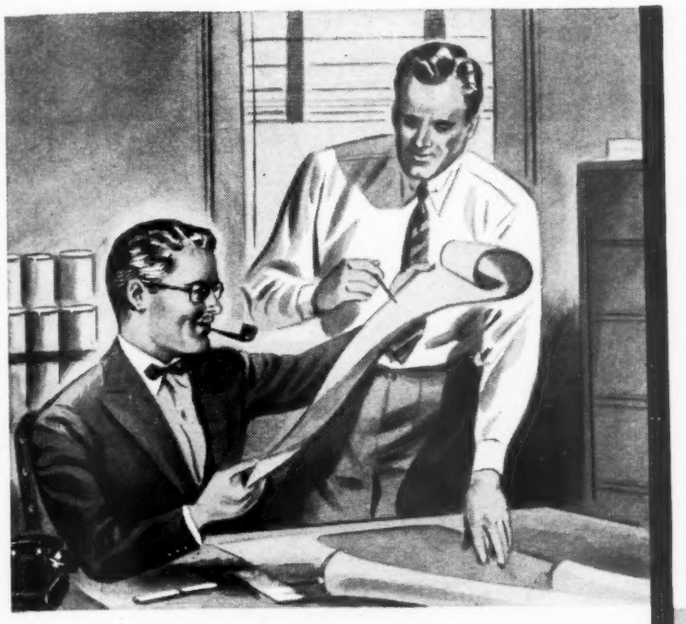
Hugoton Gas Price Okayed

An order of the Oklahoma Corporation Commission, fixing a higher price for natural gas in the Guymon sector of the three-state Hugoton field, has been upheld by the Oklahoma Supreme Court. The wellhead price (9.8262 cents per 1000 cu ft) was the second of its kind ever ordered.

The order was opposed and appealed by Natural Gas Pipeline Company of America and Panhandle Eastern Pipeline Company. Natural Gas Pipeline and Panhandle are "second purchasers" or buyers of residue gas.

What does it take to build an "Oil Bank"?





EXPERIENCE

Experience that comes from having pioneered oil production loans by commercial banks. Experience that comes from the complete consulting staff of geologists and engineers at your service at Republic.

EXPLORATION

Exploration is the essence of growth in oil production. Financing against production to make exploration possible is a primary activity at Republic. And that's what it takes to make an "Oil Bank".

This is your Republic!

REPUBLIC NATIONAL BANK of Dallas

CAPITAL AND SURPLUS $50,000,000 LARGEST IN THE SOUTH

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

Petroleum Profile

AT a state-wide meeting at Wichita last fall Theo A. Morgan, petroleum director of the conservation division of the State Corporation Commission, and the Commission were under heavy fire. Market demand for oil was down and wells had been prorated below the 25-barrels-a-day that producers generally regard as the legal minimum. Numerous operators lashed at the director and the Commission for exceeding the statutes. But other oil men jumped quickly to Morgan's defense. The final resolution was considerably di'uted, an expression largely asking the Commission to make every effort to find a bigger market for the Kansas crude.

The triumph grew out of T. A. Morgan's many years of true and faithful devotion to the double responsibility of serving the interests of the State of Kansas and of the Kansas oil and gas industry.

More than any one person, the Kansas Dean of Conservation has promoted the idea of getting the greatest value possible from the state's petroleum resources. He has been foremost in gaining for Kansas the reputation of having wise state conservation.

Morgan is highly regarded by members of the oil industry in his own state and through his activities the Interstate Oil Compact Commission is an admired figure throughout the nation's oil states. A big share of the credit for sane state regulations over the past two decades is due to Morgan. He has directed the office along policy lines set by the Kansas Corporation Commission with understanding and justice while holding a tight rein to see that rules are followed.

He was the original chairman of the Compact's regulatory practices committee and has served in the same position since.

Morgan came to Kansas with his parents in 1884 when "The Arkansas River was a buffalo trail." Theo and his twin brother, Leo, worked their way through Wichita's high school, graduating in 1900. In 1905 they entered a retail shoe business together. In 1915 Theo left the store to begin brokering producing properties and drilling for oil in Kansas. Five years later Leo, too, left the shoe store; he was active in Kansas oil until his death last October.

Theo, who is better known today as T. A., joined the old White Eagle Oil and Refining Company in 1919 (later part of the Magnolia). He headed the company's land and production departments in Texas and Oklahoma through most of eight years. After a fling at completing a company pipe line, he was also put in charge of pipe lines and crude oil purchasing for the Augusta, Ft. Worth, and Casper refineries.

T. A. MORGAN

Kansas Dean of Conservation

Morgan left the company in 1927, after "eight very pleasant years," to become an independent operator in Texas.

He came back to Wichita, Kansas, in August 1928, the same month that the state's rich Valley Center field came in from the Viola limestone with its first well flowing 1200-1500 barrels a day. He became active in Ellis County in the Shutts pool.

From 1930 to 1933 he operated as an independent in Kansas, Oklahoma, Texas, Colorado, Pennsylvania, New York and another state or two.

In January 1934, the then Governor Alf Landon selected Morgan as director of the state's oil and gas conservation division.

Proration of production in Kansas had its start in Sedgwick and McPherson counties in 1929, and the state had taken over the supervision in the summer of 1933. The choice of Morgan was one of the best the governor made. Morgan's 19 years as the state's key oil industry officer, under five governors, is proof of his experience and ability. He was out of the office for 20 months — July 1937 to March 1939 — during the term of the state's only Democratic governor in the past 20 years.

Morgan's is an oil industry family. His son, Lindsey G. Morgan, is associated with the Coleman-Stodder oil interests at Wichita. His two daughters married brothers in the oil well supply business. Theobess is Mrs. Thomas Pike of Louisville, Kentucky, and Virginia Lee is Mrs. William Pike of Belmont, California.

LETTERS

Likes Drilling Plan

To The Petroleum Engnieer:

I am particularly interested in the series of articles you have planned on "Drilling Fundamentals." I feel that these should be particularly valuable to our personnel who are not directly engaged in drilling and producing operations as a means of affording them a better understanding of these methods used and problems perculiar to such operations. I wonder if it would be possible to obtain the 55 articles in mimeograph.

D. D. Pollan

General Manager
King and Hayne

World Oil Story Helpful

To The Petroleum Engineer:

Thank you very much indeed for sending me a copy of Ernestine Adams' very interesting article "Round Up of World Oil Activities." It certainly contains in a very concise form the most useful information and I appreciate your thoughtfulness in sending me a copy.

L. F. Castle

The Shell Company
of New Zealand Limited

Bothered by Abbreviations

To The Petroleum Engineer:

As a regular reader of the Management Edition of your magazine "The Petroleum Engineer" that our faculty takes, I find on its pages some abbreviations, which seem to be of common use in your country, but are unknown to us.

As no explanantions are given in the context, nor are such abbreviations to be found in petroleum dictionaries or hand books at my disposal, I am not sure of having understood the proper meaning of those abbreviations.

For the time being I would like to have explained some abbreviations quoted in the tabular description of some U. S. wells, that follows your article "California Takes Depths Records" (The P. E. Vol. XXVI, No. 1, Pgs. B-22 and B-23).

These abbreviations are:

1.) "8RT&C," quoted with: Tide Water Well 24A Manhattan, column, casing and cementing schedule.

2.) "Cas. Pkr.," quoted with the above mentioned well, column: Perforations, production, etc. Is it meant by this abbreviation, that the pressure between the casing and the tubing equals to the critical pressure, or is meant anything else? Until now I could observe that the critical pressure was quoted as P_{cr}.

3.) "S.T.P.," quoted with: Humble No. 1 Hortense Provost-Gonsoulin, column: Perforations, production, etc. Is it the Statical tubing pressure, that is meant by this abbreviation?

4.) "CP" and "TP," quoted with: Phillips No. 2, Cosby, Texas; column: Perforations, production, etc. Is it the casing pressure and tubing pressure that is meant by this abbreviation?

5.) "PkrTP," quoted with: Phillips No. 1, Houston "S," Texas; column: Perforations, production, etc. What is really meant by that?

6.) "X," quoted after the casing and liner in the column: Casing and cementing schedule. Is it the barrel or the bag of cement, that is meant by this "X?"

7.) "Slo-set." What is the meaning, please, of this expression. It is quoted with: Tide Water No. 24A Manhattan, column: Casing and cementing schedule.

8.) "H.I.U," (9.) "Uniflow," (10.) "Strata crete." These last three are quoted with Pure Oil No. 3, West Poison, Wyoming; column: Casing and cementing schedule.

I shall be much obliged to you if you would give me details about the above mentioned abbreviations or inform me what books I could consult on them.

Svetislav Lazic

University of Zagreb
Zagreb, Yugoslavia

Abbreviations Interpreted

Letter below is reply to Professor Lazic:

In your letter of April 5 you asked about some of the abbreviations used in the table describing deep wells in the United States in the article, "California Takes Depth Records." I realize that these are not obvious but we use considerable leeway in abbreviations when they are in tables. This is largely a matter of space restrictions. Below are listed the answers to your questions:

1. RT&C — 8 round thread, threaded, and coupled.
2. Cas. Pkr. — Casing packer. In this well the tubing was run with a packer and the tubing-casing annulus sealed off. There is no involvement of critical pressures.
3. S.T.P. — Shut-in tubing pressure.
4. C.P. & T.P. — Casing pressure and tubing pressure.
5. Pkr. T.P. — Well completed with packer, hence no casing pressure recorded.
6. "X" — bag or sack of cement.
7. Slo-set — This is a type of cement commonly used in this country in deeper wells or those with elevated temperatures. The cement is a mixture of common portland cement with a chemical that retards the set of the slurry, improving pumpability and allowing more time for placement of the slurry.
8. HIU — Heavy internal upset casing. Generally used in casing strings where tension is controlling factor and collapse of less consequence.
9. Uniflow — Special type of retarded set cement. See Slo-set.
10. Strata-Crete — Cement with an additive, usually an expounded perlite, to reduce slurry weight and produce a non-shattering sheath around casing to improve gas and water control in perforated completion.

Wants 1946 PE Article

To The Petroleum Engineer:

We have a copy of an article entitled "Hydrocarbon Thermodynamics," which appeared in *The Petroleum Engineer*, April 1946, and was written by Wayne C. Edmister. This article was Part 2 of a three-part article and we would be most interested in obtaining a copy of Parts 1 and 3.

If you can supply re-prints or tear sheets kindly send them to the attention of the writer. Otherwise, we would be interested to know in what issues of *The Petroleum Engineer* the other two parts appear so that we may obtain photostatic copies from the Engineering Society's Library in New York.

W. A. McGahan

Engineer
Ingersoll-Rand Company
Phillipsburg, New Jersey

Requests Copy at Home

To The Petroleum Engineer:

Please enter my subscribtion for the Refining and Petrochemical edition. I am a chemical engineer, and am employed at the British American Refinery in Edmonton, Canada.

Although we receive several copies of your excellent magazine in the office, I prefer to have my own private subscription to my home address, where I can read the copies at leisure and keep them as a handy home reference.

Thank you, and best wishes in keeping up the quality of your excellent magazine.

Pete Miller

British American Oil Company
Edmonton, Canada

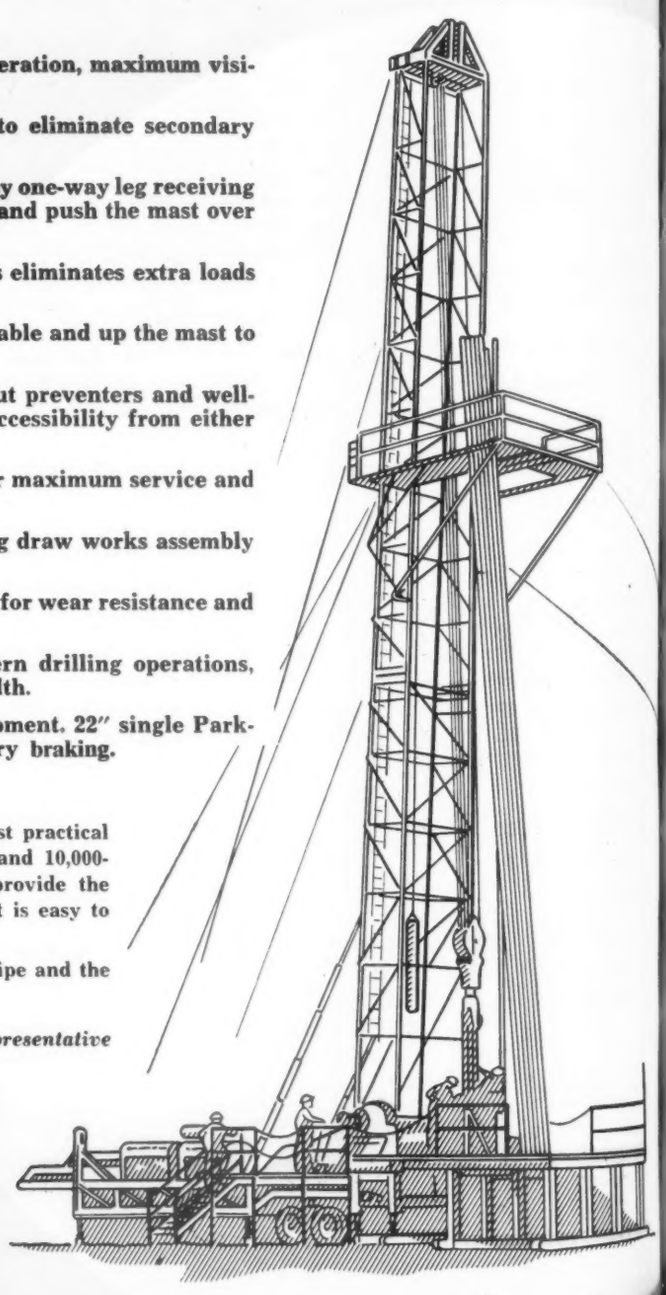
XUM

CARDWELL "TRAILERIG"

IS 15 WAYS BETTER

...than any comparable rig

1. **Mud Pump Drive is driven by draw work's engines through a Cardwell air friction clutch, which is capable of handling the full horsepower of the rig. Full horsepower of the rig can be used for hoisting and for driving the rotary and pump when drilling. Moving and rigging up is simplified with this built-in mud pump drive.**
2. **"Trailerig" with two engines is within eight feet road width for maximum portability regardless of the overall length of the engines. Placement of engines eliminates eccentric loading and engine overhang.**
3. **Truss-type trailer frame gives exceptional strength and rigidity with minimum weight.**
4. **All rig assemblies are easily accessible.**
5. **Catheads are located ahead of driller for ease of operation, maximum visibility and safety.**
6. **Single chain rotary drive is placed well forward to eliminate secondary chain drives to table.**
7. **One-way rams erect the mast and are supplemented by one-way leg receiving rams which support the mast as it goes over center and push the mast over center when lowering.**
8. **No trailer ramp is needed with the "Trailerig"; this eliminates extra loads and rig-up time.**
9. **Driller has maximum visibility, both to the rotary table and up the mast to the racking platform and crown.**
10. **Ample space is provided under platform for blowout preventers and wellhead connections without using ramps. Complete accessibility from either side.**
11. **Crown sheaves are mounted on Timken bearings for maximum service and life.**
12. **"Trailerig" is a completely unified design combining draw works assembly and telescoping mast with trailer frame.**
13. **Every wearing part of the "Trailerig" is heat-treated for wear resistance and long service life.**
14. **Two-engine drive gives power necessary for modern drilling operations, yet the "Trailerig" does not exceed 8-foot road width.**
15. **Circulating water-cooled brakes are standard equipment. 22″ single Parkersburg Hydromatic brake is available for auxiliary braking.**



This Cardwell "Trailerig" has proved to be the most practical and profitable rig available for 5,000-foot drilling and 10,000-foot workover jobs. It is designed and built to provide the modern drilling contractor with a complete rig that is easy to move and rig-up, and fast in operation.

With the addition of a mud pump, a string of pipe and the usual tools, the "Trailerig" is ready to drill.

Write today for catalog and prices, or see nearest Cardwell representative

CARDWELL MFG. CO. INC.

P. O. Drawer 2001 . . . Long Distance Telephones 128—129—130
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Wichita, Kansas, U. S. A.

IT BEGAN WITH A RAFT AND A BOLD ARMENIAN

ABOUT 500 years B.C., an Armenian merchant, looking for new markets, resolved to take a "capital risk".

He loaded a raft with stretched-hide containers of asphalt and bitumen, plus a half dozen asses, and floated hundreds of miles down the Euphrates to Babylon.

His venture paid off. He sold his wares at a profit, and he and his crew rode home on the backs of their animal passengers.

So was taken the first step in the water transportation of petroleum products.

Some 2,400 years after, the latest step is taken:

April 20, 1954, saw the launching of the first of four Cities Service super tankers as queens of the world's oil carriers, the latest additions to the Cities Service fleet. Their size and appointments should make even today's tanker men—much less our Armenian friend—gape with astonishment.

They will carry more oil in less travel time than any other tankers in service today. Air-conditioned, with individual staterooms for all, they'll have crew comforts and conveniences never before seen on tankers.

They will be, in short, the latest word in oil transportation. Not the "last word"—for there is no such thing. (The Armenian probably thought *he* had it!)

The four new "luxury liners" of the Cities Service fleet are merely the latest chapter in a long, long story ... AND THE END IS NOT YET.

CITIES SERVICE

Quality 5-D Products

XUM

PETROLIC PERSONALITIES

DICK SNEDDON

THINGS ARE BUZZING IN THE FAR WEST

These have been hectic times out in the far west what with the May Fete at the Los Angeles Petroleum Club, the API division of production spring meeting at the Statler Hotel, the spring barbecue of the Petroleum Production Pioneers at Brea, and a thick schedule of other affairs mostly falling in the first two weeks of May, your correspondent has been busier than a Buff Orpington chicken that has inadvertently stepped on a fly paper.

The May Fete was very lovely affair hostessed very charmingly by Mrs. S. F. Bowlby and her assisting ladies who had earlier transformed the club rooms into a beautiful Maytime arbor replete with gorgeous blossoms, butterflies, Maypoles, and all the appropriate accoutrements of balmy spring. On the receiving line—and a luscious thing it was if we do say so—were Mesdames S. F. Bowlby, W. L. Heater, E. A. Pellegrin, H. K. Said, J. D. Hughes, D. A. Carnahan, and Miss Virginia Miller.

At this affair some 200 interesting oil people were warmly welcomed, first to a stimulating cocktail session, next, to a fine buffet dinner, and finally to a dance program for which the music was provided by a provocative aggregation of beboppers. It was by all means a thoroughly enjoyable soiree and we have it on good authority that some of its heavier vibrations rocked the seismograph at Mount Wilson.

WE MEET SOME CONTINENTAL NOBLEMEN

A couple of days later we had the pleasure of attending a press party staged by Olen Lane, vice president of Continental Oil Company. This affair was attended by delegates from all the metropolitan newspapers and the oil magazines, and was designed to introduce Emerson Smith, Continental's public relations chief at Houston, to the western oil and financial writers. Also present from Continental was Roy Barnes, chief geologist for the company's western division, and one of the most devasting domino players.

The meeting was productive of much that was educational and elevating for all who had the good fortune to be present. The only discouraging aspect of the whole thing was our failure to introduce Emerson Smith to anyone he didn't already know, either by correspondence or otherwise.

COMPARING THE SUMANS IS FUN

During the course of the API spring meeting in the Los Angeles Statler, at which Milan Arthur presided most capably with John Suman, vice president of Standard of New Jersey, whose presentation on the cultivation of an executive crop was one of the highlights of the convention. Knowing John's brother George, a Tide Water Associated higher-up, intimately, we found the comparison of personal attributes an interesting process.

They are both friendly chaps who appear to enjoy fully the opportunities that their respective positions offer for fraternization with their petrolic brothers, and they both exhibit an almost complete detachment when they are mulling over momentous problems. This is a quality we have noted in other people with unusual powers of rationalization.

We think of Henry Paulsen, the Bankline Oil Company vice president, as another of these geniuses. You can almost hear Henry's mind at work grinding out the solution when a problem is posed—about like a cigarette machine after you have put in your quarter.

EVERYBODY WAS THERE

We accepted Standard of Cal's invitation to foregather with the boys at the University Club prior to the API dinner and had a grand time exchanging small talk with the elite of western oil. Among the hosts we found Warren Johnson, Mal Morris, Bill Cochems, Elmer Olsen, and Bob Roberts from the southern area, and Jules Toussaint, Jim Gosline, and Graham Moody from San Francisco, and, of course, there were other consequential Chevronites, too.

It is rather futile to attempt to name the entire list of guests but we did see such notables as Doug Graham, the world girdling contract driller; Bob Cook, the Great Lakes Carbon executive; Ted Sutter, the Baker Oil Tools and PESA higher-up; Frank Morgan, the recently resigned Richfield Oil Corporation vice president; L. L. Aubert, president of Banklin Oil Company; Don Grubbs, the Oil Well Supply Company biggie; Ben Balliss, Lloyd Corporation engineer; Sam Grinsfelder, Union Oil Company veep; Jerry Evans of National Supply Company fame; Elmer Wycoff, National Tube Company's widely known representative; Ed Stearns, the eternally young Universal Consolidated Oil Company pioneer; Tom Selser, the retired Macconian, and so on.

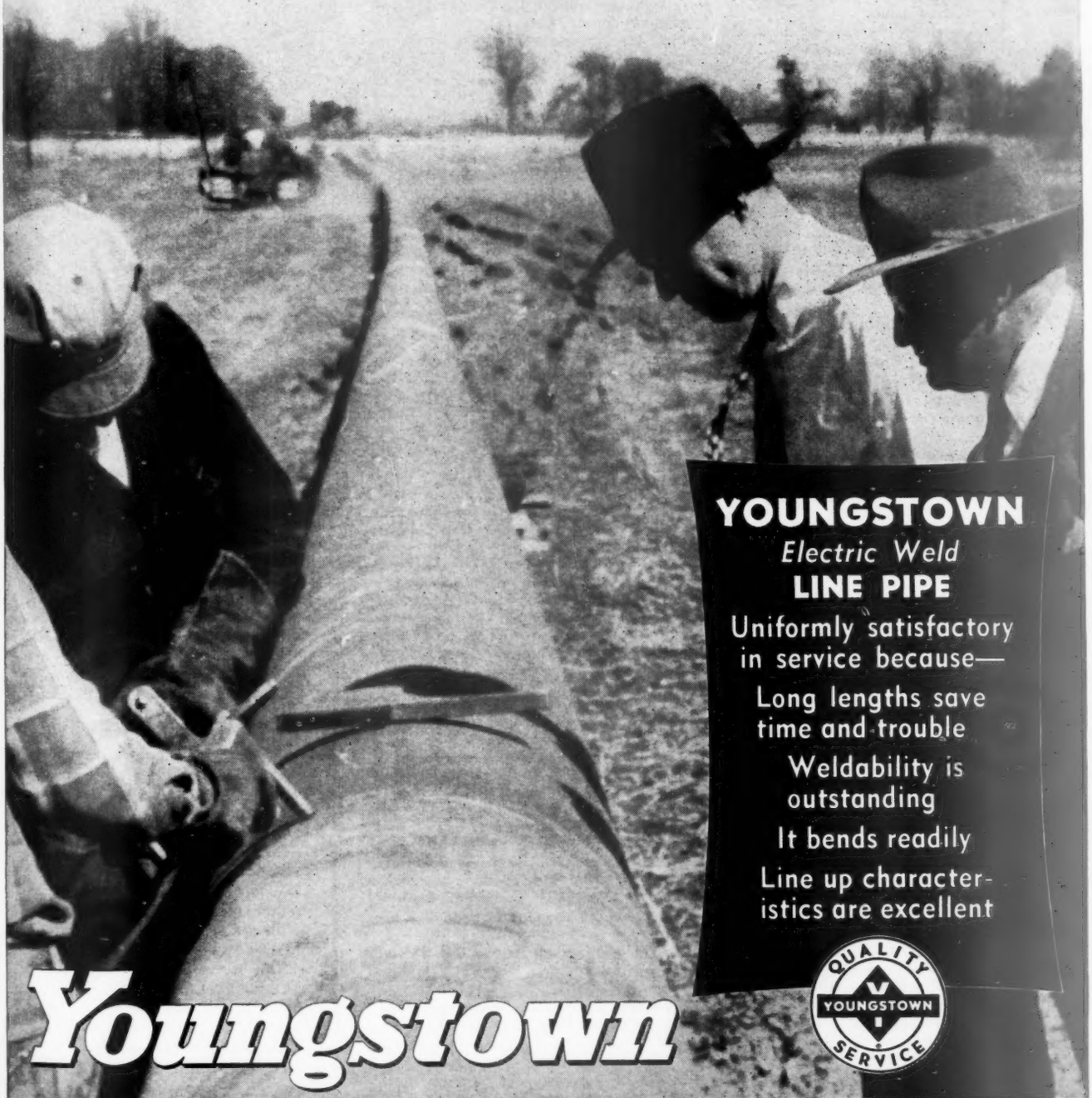
BITS OF THIS AND THAT

By way of last-minute roundup, Norman Anderson, Richfield's manager of pipe lines has just been appointed president of the Western Pipe Liners' Club. Norm is an athletic sort of chap who once represented the United States in the Olympic Games. He also has the unique distinction of having kicked off the first game in the present Rose Bowl at Pasadena and the first game in the Los Angeles Coliseum when he played tackle for USC back in 1923.

"WHO'D YOU SAY YOU BEEN DRILLIN' FOR ?"

Yes, it's Youngstown

THE EXCELLENT WELDING QUALITIES of Youngstown line pipe are evident on every job. Pipe line contractors who are becoming increasingly critical of pipe features which add to their costs welcome this easy-to-weld pipe.



YOUNGSTOWN
Electric Weld
LINE PIPE

Uniformly satisfactory in service because—

Long lengths save time and trouble

Weldability is outstanding

It bends readily

Line up characteristics are excellent

QUALITY YOUNGSTOWN SERVICE

Youngstown

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

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PIPE AND TUBULAR PRODUCTS - CONDUIT - BARS - RODS - COLD FINISHED CARBON AND ALLOY BARS - SHEETS - PLATES - WIRE - ELECTROLYTIC TIN PLATE - COKE TIN PLATE - RAILROAD TRACK SPIKES

MEETINGS ★

June 6-11—**Society of Automotive Engineers,** summer meeting, Ambassador and Carlton Hotels, Atlantic City, New Jersey.

June 9-11—**Oil Industry Information Committee,** Edgewater Beach Hotel, Chicago.

June 13-18—**American Society for Testing Materials,** annual meeting and exhibits, Sherman and Morrison Hotels, Chicago, Illinois.

June 14-17—**American Society of Mechanical Engineers,** Oil and Gas Division, conference and exhibit, annual, Hotel Muehlebach, Kansas City, Missouri.

June 17-19—**American Petroleum Institute,** Division of Production, Eastern district, Greenbrier Hotel, White Sulphur Springs, West Virginia.

June 17-19—**National Oil Scouts and Landmen's Association,** annual, New Orleans, Louisiana.

June 20-25—**American Institute of Chemical Engineers and Institute of Nuclear Energy,** University of Michigan, Ann Arbor, Michigan.

June 20-24—**Canadian Gas Association,** Banff Springs Hotel, Banff, Alberta, Canada.

June 21-25—**Gordon Research Conference on Petroleum,** Colby Junior College, New London, New Hampshire.

June 20-July 4—**California Institute of Technology,** annual conferences on Personnel Administration and Managerial Development, Industrial Relations Section, Pasadena, California.

June 21-25—**American Institute of Electrical Engineers,** combined summer and Pacific general meeting, Biltmore Hotel, Los Angeles, California.

June 24-25—**Western Petroleum Refiners Association,** regional, Leonard refineries auditorium, Alma, Michigan.

June 27-July 1—**Petroleum Equipment Suppliers Association,** Manior Richelieu, Murray Bay, Quebec, Canada.

July 21-24—**Human Relations in Industry Conference** (YMCA), Silver Bay, New Jersey.

Aug. 16-18—**Society of Automotive Engineers,** international West Coast meeting, Georgia Hotel, Vancouver, B. C., Canada.

Aug. 23-25—**Appalachian Gas Measurement Short Course,** annual, West Virginia University, Morgantown, West Virginia.

Aug. 26-28 (tentative)—**Intermountain Association of Petroleum Geologists,** annual field conference, Price, Utah.

NOMADS TO MEET

New York, N. Y., Chapter, First Monday of the Month, Biltmore Hotel, New York. Secretary, O. B. Latrobe.

Houston Chapter, Second Monday of the Month, Ye Olde College Inn, Houston, Texas. Secretary, Harry E. Estes.

Los Angeles Chapter, Second Wednesday of the Month, Jonathan Club, Los Angeles, Calif. Executive Secretary, Wallace A. Sawdon.

Tulsa Chapter, Third Friday, "After Five" Room, Hotel Tulsa. Secretary, Gilbert Swift.

Dallas-Fort Worth Chapter, Dallas, Texas. First or Second Monday of the Month. Secretary, Glen Tableman.

Sept. 6-11—**American Chemical Society,** national meeting, Conrad Hilton Hotel, Chicago, Illinois.

Sept. 7-8—**Association of Desk and Derrick Clubs of North America,** annual convention, Banff Springs Hotel, Banff, Alberta, Canada.

Sept. 8-10—**Oil Industry Information Committee,** Chicago, Illinois.

Sept. 8-10—**Pacific Coast Gas Association,** annual, Vancouver Hotel, Vancouver, B. C.

Sept. 9-11—**Interstate Oil Compact Commission,** Omaha, Nebraska.

Sept. 12-16—**American Institute of Chemical Engineers,** Colorado Hotel, Glenwood Springs, Colorado.

Sept. 13-14—**Independent Natural Gas Association of America,** annual, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 13-24—**Instrument Society of America,** International Instrument Congress and Exposition and National Instrument Conference and Exhibit, Philadelphia, Pennsylvania.

Sept. 15-17—**National Petroleum Association,** annual, Traymore Hotel, Atlantic City, New Jersey.

Sept. 16-17—**Mid-Continent Oil and Gas Association,** Louisiana-Arkansas Division, annual, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 23-24—**Western Petroleum Refiners Association,** regional, Henning Hotel, Casper, Wyoming.

Sept. 27-30—**American Society of Mechanical Engineers,** Petroleum Division, annual, Statler Hotel, Los Angeles, California.

Sept. 27-29—**American Institute of Electrical Engineers,** electrical conference for petroleum industry, Mayo Hotel, Tulsa, Oklahoma.

Oct. 4-6—**Petroleum Electric Power Association,** annual, Jung Hotel, New Orleans, Louisiana.

Oct. 4-6—**Texas Mid-Continent Oil and Gas Association,** annual, Plaza Hotel, San Antonio, Texas.

Oct. 6-8—**Technical Conference on Petroleum Production,** annual, Mineral Industries Building, Pennsylvania State College, State College, Pennsylvania.

Oct. 7-8—**American Institute of Mining and Metallurgical Engineers,** Pacific Petroleum Chapter, Fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 7-8—**California Natural Gasoline Association,** annual, Ambassador Hotel, Los Angeles, California.

Oct. 11-13—**American Association of Oil Well Drilling Contractors,** annual, Biltmore Hotel, Los Angeles, California.

Oct. 11-14—**American Gas Association,** Atlantic City, New Jersey, hotel to be named.

Oct. 12-15—**National Chemical Exposition,** annual, Chicago Coliseum, Chicago, Illinois.

Oct. 14-17—**Permian Basin Oil Show,** Odessa, Texas.

Oct. 17-20—**American Institute of Mining and Metallurgical Engineers,** petroleum division, Fall meeting, Plaza Hotel, San Antonio, Texas.

Oct. 24-26—**Independent Petroleum Association of America,** annual, Mayo Hotel, Tulsa, Oklahoma.

Oct. 25-29—**American Institute of Electrical Engineers** (tentative date), Fall general meeting, Chicago, Illinois.

Oct. 26-27—**Society of Automotive Engineers,** national diesel engine meeting, Statler Hotel, Cleveland, Ohio.

Nov. 1-5—**American Society for Metals,** national, Palmer House, Chicago, Illinois.

Nov. 4-5—**Society of Automotive Engineers,** national fuels and lubricants meeting, Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-11—**American Petroleum Institute,** annual, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Dec. 2-4—**Interstate Oil Compact Commission,** Winter meeting, Drake Hotel, Chicago, Illinois.

Dec. 8-10—**Oil Industry Information Committee,** Waldorf-Astoria Hotel, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual, Statler Hotel, New York, New York.

1955

March 9-11—**American Petroleum Institute,** Southwestern District, Division of Production, Jung Hotel, New Orleans, Louisiana.

March 20-23—**American Institute of Chemical Engineers,** Kentucky Hotel, Louisville, Kentucky.

April 19-21—**Southwestern Gas Measurement Short Course,** University of Oklahoma, Norman, Oklahoma.

May 1-4—**American Institute of Chemical Engineers,** Shamrock Hotel, Houston, Texas.

May 14-22, 1955—**Deutsche Gesellschaft fur Chemisches Apparatewesen,** chemical plant and apparatus exhibition and congress, Frankfurt am Main, Germany.

June 1-9, 1955—**Fourth World Petroleum Congress,** Rome, Italy.

Sept. 12-16—**Instrument Society of America,** National Instrument conference and exhibit, Los Angeles, California.

Sept. 25-28—**American Institute of Chemical Engineers,** Lake Placid Club, New York, New York.

Nov. 14-17—**American Petroleum Institute,** annual, San Francisco, California.

Nov. 27-30—**American Institute of Chemical Engineers,** annual, Statler Hotel, Detroit, Michigan.

Nov. 28-Dec. 3—**American Society of Mechanical Engineers,** Statler Hotel, New York, New York.

Dec. 12-15—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, New York, New York.

PETROLEUM CONFERENCE

Eighteen technical sessions have been planned for the ninth annual Petroleum Mechanical Engineering Conference in Los Angeles, California, September 27-30.

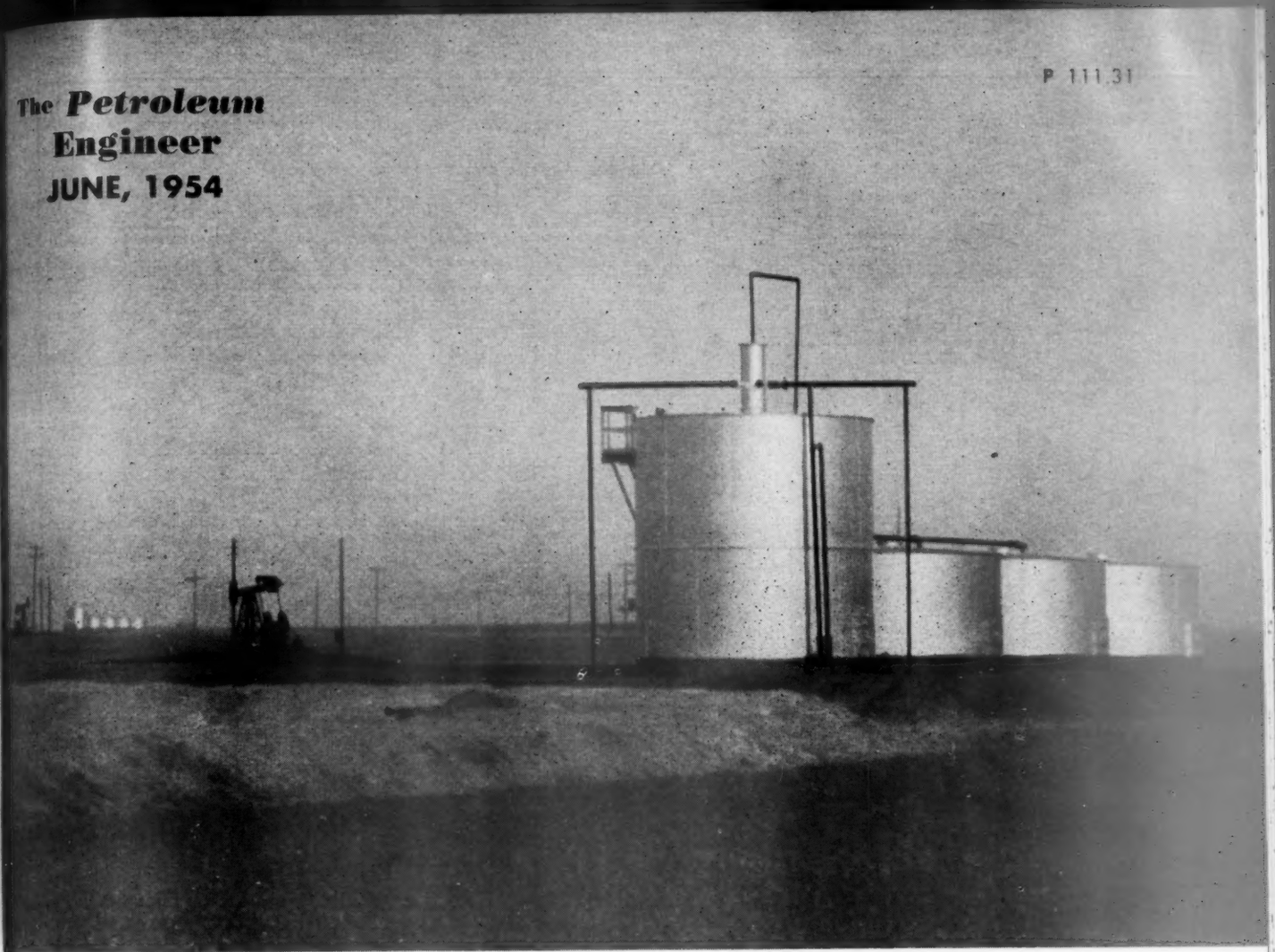
L. F. Strader, assistant vice president for manufacturing, Richfield Oil Corporation, is handling arrangements. Between 800 and 1000 engineers are expected to attend the 3-day session. Headquarters will be in the Statler Hotel.

Committees in charge are planning special planes from Dallas, New York, Tulsa, Houston and Chicago to the convention.

Topics of interest to engineers are scheduled under four main headings: Production, Transportation, Refining, and Materials. In addition to the technical sessions, committee meetings, banquets and luncheons are slated.

The Petroleum Engineer
JUNE, 1954

P 111.31



Pumps and storage tanks in a field in McPherson County, Kansas, north of Wichita. — *Courtesy Derby Oil Company*

Here is a "blue chip" oil and gas state — For 94 years it has shown a steady trend of improvement and expansion in every phase of the industry: New fields, production of oil and gas, refineries, natural gasoline plants, pipe lines, and storage

Look at What Kansas Is Doing!

ERNESTINE ADAMS*

KANSAS is the venerable senior member of the Mid-Continent oil states but the state oil industry isn't growing old — it is simply growing bigger and more modern. There are more ideas and deals to the square mile in Kansas than you'll find from New York to California.

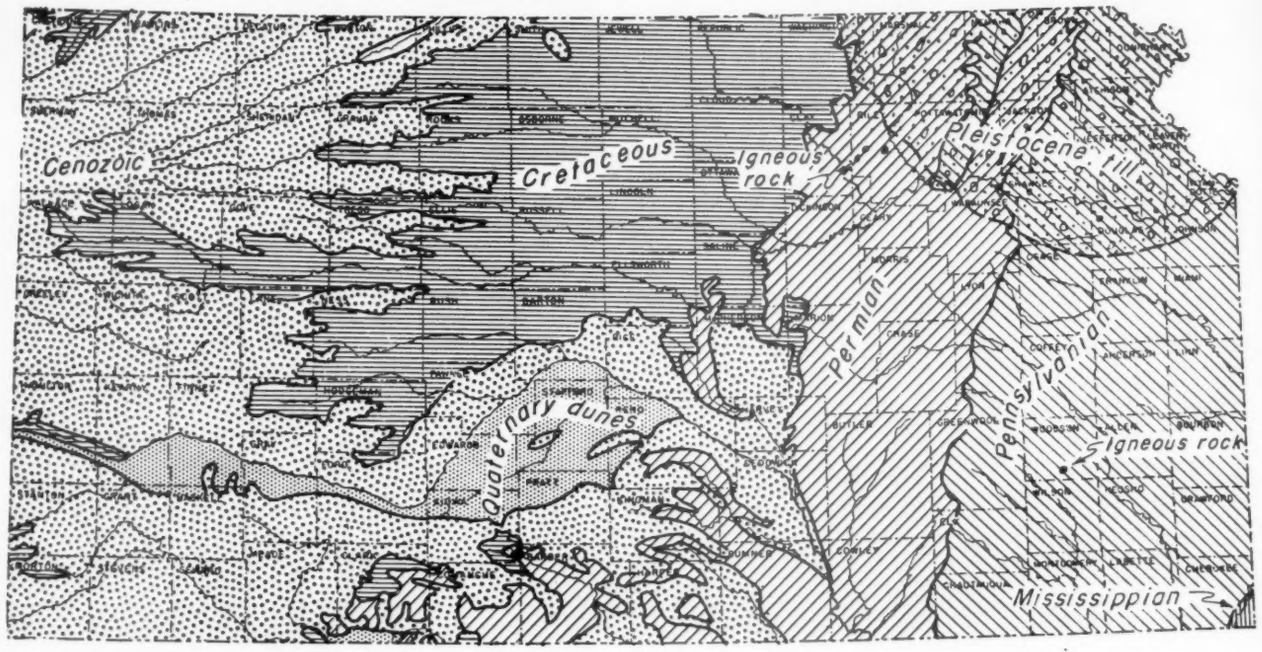
The Kansas petroleum industry is conservative in the most radical way. It is adult in its thinking, persistent in making a dollar, determined in making its own decisions; then to offset all this bland sanity, it experiments with any idea that comes along to separate hydrocarbons from limestone crypts and is so often successful that dead oil fields are never at rest.

Kansas has been swarmed over time and again by operators in search of oil. They came from the East, the South and the North — they even came from Kansas. Yet today the state still has a high ratio of discoveries to wildcats drilled. It's a cake with a lot of hydrocarbon filling and after some 94 years of sticking holes in the frosting, an enterprising operator still has a good chance.

But the enterpriser had better be aware of Kansas' ways and be strong for Kansas' good because in this hunting ground of the small operator, com-

*Managing Editor.

EXCLUSIVE



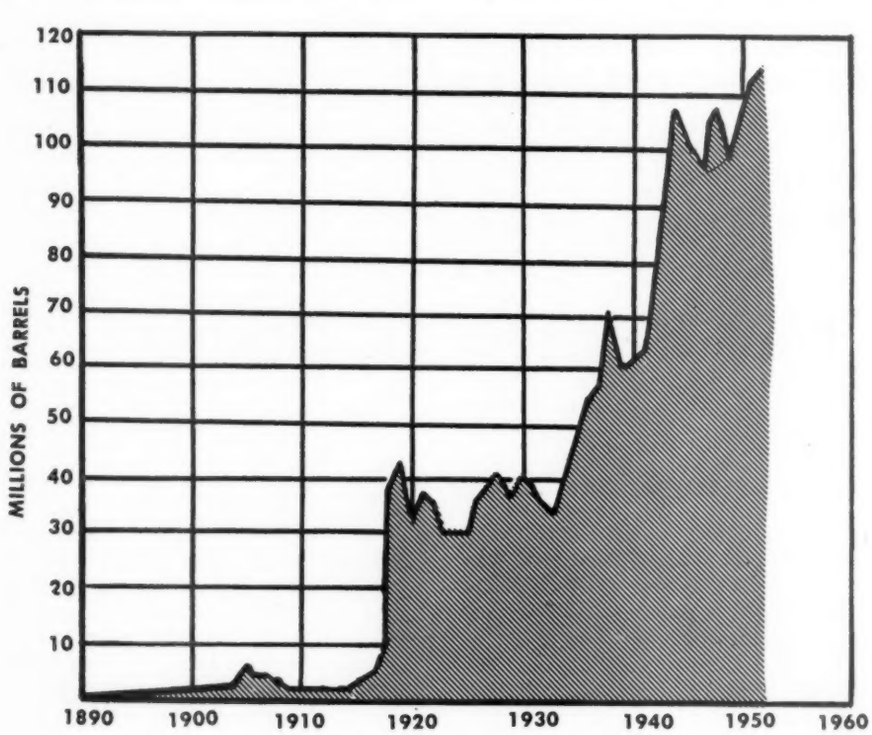
Generalized geologic map of Kansas shows the varied geologic ages that out crops over the state.
— From "Kansas Rocks and Minerals"

petition will be breathing down his neck every step of the way.

There is a fine cooperation among the thousands of small operators, too. "We give away millions of dollars worth of information," said one operator. "We give it even when the guy is working across the fence and probably will take some of our oil." It's true. But altogether the information works out to more oil for all operators.

History

Herald of Freedom, a Lawrence, Kansas, newspaper, carried the following item in the July 25, 1859 issue:



Annual oil production in Kansas from 1890 to 1953 shows the spectacular growth of output, especially since the El Dorado field was discovered in 1916. Production has almost tripled in this period.
—From "Oil and Gas Developments in Kansas During 1952."

"We learn from R. S. Stevens, Esq., that a valuable petroleum, or rock oil has been discovered some 8 miles northeast of Paola. He states that it can be collected in the amount of several gallons daily."

Stevens was an engineer who had been employed to lay out Lawrence and his interest in geology led him to the oil seeps. A newspaper editor, Dr. G. W. Brown, of Conneautville, Pennsylvania, said to have been influenced by Stevens' report as well as an earlier report by A. D. Searle, moved to Lawrence and organized the first oil company in the state, known as Brown, Solomon and Company. East of Paola the company found heavy oil at 275 ft.

Gas was highly important to the Kansas of those days, too. It was first discovered near Kansas City and later in other eastern counties, bringing great industrial development in the latter part of the 19th century.

Exploration

This early search for oil and gas was limited to shallow fields in East Kansas. In the years since subsurface data have been collected and accumulated by the State Geological Survey of Kansas. The great plains with waving wheat are a calm cover of the many upheavals in the geologic past.

An inland sea advanced and retreated with the depression and elevation of the land. Siltation and erosion alternated over long periods. Rocks of early ages were tilted and cause rocks of various geologic periods to crop out all over the state's surface. (See map.)

The fact that only 11 out of the 105 counties of Kansas do not have some acreage leased indicates how widespread the potential in the state is believed to be. The 15,456,300 acres under lease January 1, 1954, represents almost 30 per cent of the entire area of Kansas.

In 1953 close to 900 wildcat wells were drilled in Kansas, more than in any state outside Texas. Out of every 5 exploratory wells drilled, an oil or gas field was discovered. Dr. J. M. Jewett, of the State Geological Survey says 187 new oil and gas fields were found in 1953 and 250 new pools were discovered in established fields. Gas pool discoveries of 24 new fields more than doubled the records for any previous year and oil field discoveries of 163 were 20 more than in 1952.

Production

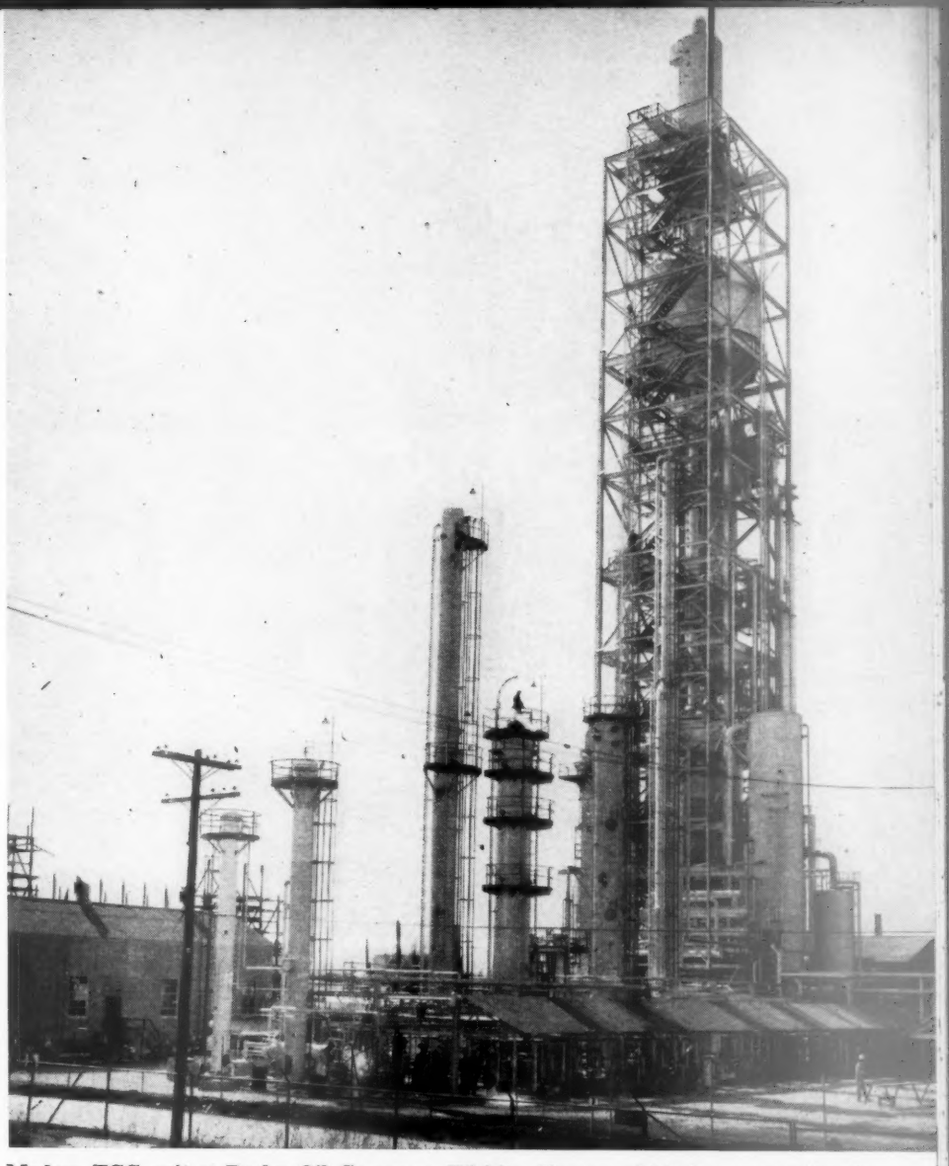
This concentrated exploration activity pays off in good production. Record production of 114,400,000 bbl in 1952 was met again in 1953 despite a 10-day complete shutdown because of oversupply above ground.

Production of natural gas, almost entirely from the fabulous Hugoton area in southwest Kansas, amounted to 421 billion cubic feet from 5722 wells in 1953, a new record. The total in 1952 was 365 billion cubic feet.

Discovery of the Hugoton gas area was in 1922 but its distance from consuming centers slowed its development. Full operations awaited the coming of the big gas transmission lines that carry the fuel to population centers in the North and East.

Recent expansion of the new Greenwood pool in Morton County, extreme southwest corner, is providing new gas resources. Another interesting development is discovery of oil within the confines of the Hugoton gas area. Cities Service found the first oil in the area and in recent weeks Helmerick and Payne at one location and Bennett and Roberts at another have added new discoveries of oil.

Natural gasoline and LPG output ran more than 5,000,000 bbl in 1953 There are 17 natural gasoline plants in the state.



Modern TCC unit at Derby Oil Company, Wichita, Kansas, which has a capacity of 15,000 bbl a day. *—Courtesy Derby*

Reserves

Kansas ranks sixth in proved oil reserves as estimated by the API. As of December 31, 1953 crude reserves were set at 913,341,000 bbl. Including liquid hydrocarbons brings this to a total of 1,091,096,000 bbl.

In natural gas reserves, Kansas ranks fourth. Only Texas, Louisiana, and New Mexico are credited with reserves totaling more than Kansas' 15,788 billions cubic feet of natural gas. Some 14,000 billions are credited to the Hugoton area. Proved reserves increased 11 per cent in 1953, the increase being 60 per cent greater than the year's production.

Secondary Recovery

In Eastern Kansas there is an estimated 250 million barrels of oil recoverable by water flooding.

The famous El Dorado field,* which has produced more than any other Kansas pool, is the leading field in secondary recovery projects but it has only a few of some 180 projects in the state.

New or revised methods of repressuring by injection of water, air, or gas, or a combination of these are given concentrated attention. The Spearow method of vertical air repressuring in Osawatomie, Kansas, and flame flooding in North Oklahoma, just below the Kansas line, are recent contributions to possible techniques in this phase of the industry.

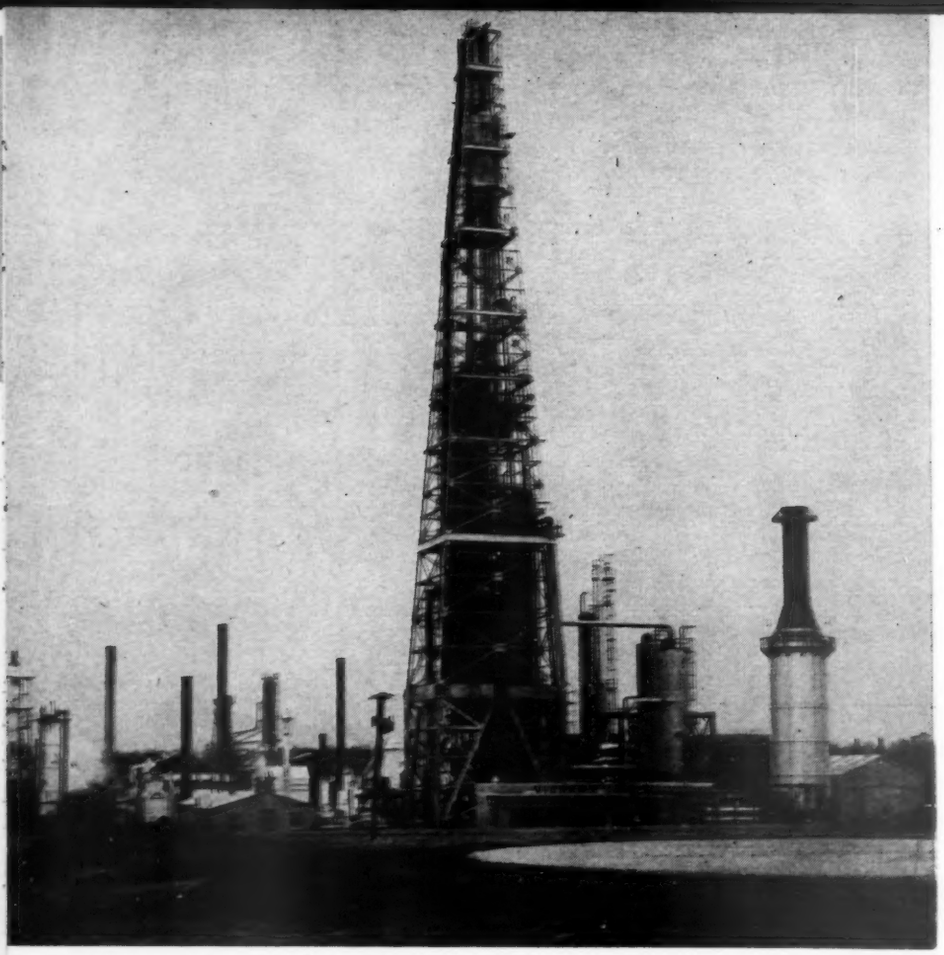
The importance of secondary recov-

*See Page E-2 this issue for a background article on this amazing oil field where many modern methods were pioneered.

KANSAS IN REVIEW

This brief summary does little justice to the great oil and gas industry of Kansas but it is only an introduction for the other articles in this issue, which go into the operations with more detail.

Three more articles will be published next month. Like these, they have a Kansas background but the techniques can be applied in other states.



Vickers refinery at Potwin, Kansas, northeast of Wichita, has a 12,000 bbl a day capacity. The catalytic cracking unit is 265 ft high. *—Courtesy Vickers Petroleum*

ery can be found in a single sentence in the volume on "Oil and Gas Developments in Kansas during 1952," published by the University of Kansas Press for the State Geological Survey of Kansas.

"Only one pool was officially abandoned during 1952," reads the report.

Refining

The state has 13 refineries (see table) with a total capacity of 265,000 bbl a day. All of these have added new facilities in recent years.

The Neodesha refinery of Standard of Indiana is the oldest of those operating. It began refining 500 bbl a day in 1897. Phillips and Skelly have the two largest plants, together processing more than one-third of the 88 million barrels of oil run to stills in Kansas (1953).

Derby's new units have given the company a big boost. Derby sold 20 per cent more the first quarter of 1954 than the same period in 1953.

Vickers may be the last integrated company owned by one family. The company, which has production, refinery, pipe lines and markets, is reputed to be very successful but financial statements are not released.

Three carbon black plants in Kansas processed 11 billion cubic feet of natural gas and 57,723 bbl of LPG to produce 70 million pounds. Value at the plants was $3,207,600. Production of carbon black in the state is falling off.

Storage

The strong belief in conservation that is particularly evident in Kansas moves naturally into storage problems — to conserve products when markets are limited and to keep them available when they are needed. Depleted salt water, gas, and distillate sands and former salt beds are used for LPG storage.

Caldwell, the Kansas manufacturer of oil well rigs, has recently developed a rig to be used to rework old wells for the purpose of making a completely sealed underground storage zone.

State Geological Survey

The local approach to problems is seen in the state's organization for its subsurface resources.

Kansas has the best State Geological Survey in the nation—till somebody comes along and proves different. It is set up with the idea of Kansas making the most of their natural resources and Kansas is doing that and more.

With headquarters at the State University in Lawrence, the State Geological Survey is one that could be studied with benefit by other states.

Conclusion

It would take more space than this article requires to acknowledge individually the indebtedness for articles and data that came from Kansas operators and their associates. Not only does the state's industry have the same dynamic quality that is the gift of the industry as a whole but it possesses larger experience than most petroleum states and has a great heritage of information and know-how that can be used to advantage by other states.

Kansas sets an example for all petroleum states in its excellent conservation program, its individual, yet cooperative, approach to oil problems, its evident good stewardship of natural resources, and its open-mindedness to adventures in greater progress. * * *

ACTIVE REFINERIES IN KANSAS

Company	Place	Capacity B/D
Phillips Petroleum Company	Kansas City	55,000
Skelly Oil Company	El Dorado	40,000
Socony-Vacuum Oil Company	Augusta	28,500
Cooperative Refinery Association	Coffeyville	25,000
National Coop. Refinery Association	McPherson	26,500
Standard Oil Company	Neodesha	20,500
Derby Oil Company	Wichita	15,000
Anderson-Prichard Oil Corporation	Arkansas City	12,500
El Dorado Refining Company	El Dorado	12,000
Vickers Refining Company	Potwin	12,000
Cooperative Refinery Association	Phillipsburg	8,000
Bay Petroleum Corporation (Shut down permanently in November 1953)	McPherson	
Shallow Water Refining Company	Shallow Water	4,000
Missouri Farmers Association (M.F.A.)	Chanute	2,000
TOTAL		265,000

FRANKS *Offers* The MOST RUGGED Servicing Units with the *Strongest Heart*

The Power Take-off, a Franks *first* in 1931, is what made possible the self-propelled servicing unit, economically using the truck motor for hoist power and providing legal weight units. Franks (split shaft right angle gear box) PTOs, like Franks units, are rugged. Don't take a PTO with less field proven and tested experience than Franks.

Franks PTOs are fully field tested with over 2,000 in use

Rocket

One of four 65 TD Franks Rockets owned by Coon Well Service Co., Liberty, Texas

Franks units are noted for speediest rig-up and down, fastest location-to-location moving, fastest pulling, ease of operation, trouble-free operation. Here are features of Franks superior derrick type mast:

- ★ **Made of seamless mechanical steel tubing for greatest strength and lightest weight.**
- ★ **Franks rated capacity 100,000 lbs. (gross structural capacity 189,000 lbs.)**
- ★ **Double acting hydraulically raised and hydraulically extended.**
- ★ **Extension lock operates automatically up or down.**
- ★ **Safety check on hydraulics will not allow derrick to drop during raising or extending.**
- ★ **Greater derrick depth provides greater stability.**
- ★ **Tilt adjustment for irregular locations saves rig-up time.**
- ★ **Hydraulic raising devices out of way so there is no impediment to line spooling operation under standard derrick.**
- ★ **Front legs form a straight line from ground to crown.**
- ★ **No guy line rigging to ground necessary.**

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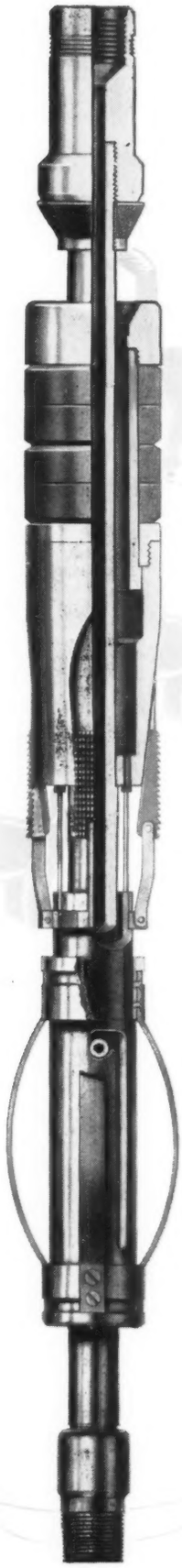
Only Franks offers "on the spot" field service with stock of parts and factory trained personnel available at: Alice, Compton, Casper, Farmington, Great Bend, Houston, Kilgore, Odessa, Seminole, Edmonton, and Tulsa.

XUM

More lives than a cat!

and here's why

Each one of the 54 parts in this typical *LANE-WELLS Packer* is built to function under tougher conditions than you'll ever find in the oil fields.



Oil country men...men who know, first hand, what oil well operations demand...designed all the 12 different types of Lane-Wells Packers and laid down the tough specifications for every part. That kind of engineering pays off in long, satisfactory service life, as is shown in the hundreds of reports from operators. They tell of Lane-Wells Packers used on job after job, setting surely, packing off well fluids for long periods of time, pulling easily and coming up ready for further service. Truly, Lane-Wells Packers have nine lives!

Tomorrow's Tools - Today!

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Exploration, Drilling, Producing

Tide Water Reorganizes

Tide Water Associated Oil Company has announced that its Mid-Continent operations have been reorganized and headquartered from two division offices, the central division at Tulsa, Oklahoma, and the southern division at Houston, Texas. Reorganization was made in order to administer more effectively the company's expanding program of exploratory and development activities.

J. E. Roth has been appointed general manager of the central division, and E. B. Miller, Jr., has been appointed general manager of the southern division.

★ ★ ★

California Unit Formed

A voluntary unitization program among six participating companies, covering 1360 acres in the Coalinga Nose oil and gas field, Fresno County, California, has been formed. The Los Nietos Company will be operator of the Vaqueros Zone Unit.

Los Nietos drilled the Vaqueros zone discovery well about two years ago. Initial flowing production of 1300 bbl per day of 38 deg gravity crude oil was obtained at a depth of 6449 ft. The well was shut in, however, pending formulation of the Unit Plan.

★ ★ ★

Cambrian Manual

Five Star Oil has issued a new reference work on the Cambrian Trend in West Texas, describing the play as the "most important recent development in Texas." The publication traces the development of the operation from the first production in Pecos County in 1939 to the present excitement in Nolan County. Included is a geological treatise and complete field and well histories with numerous electric logs and maps.

★ ★ ★

Texas Exploration Up

After a decline in 1953, exploration in Texas has returned to a high level. Through mid-May there have been 266 new fields discovered, 62 more than for the comparable period last year, with gas strikes accounting for 39 of the total. Mid-May production — some 10 per cent under the allowable — is estimated at 2,646,000 bbl per day.

Geologists Meet

The Gulf Coast Association of Geological Societies will hold its fourth annual meeting November 3 through 5 at the Rice Hotel in Houston. Member societies who will be represented include Baton Rouge, Corpus Christi, East Texas, Houston, Mississippi, New Orleans, Shreveport, South Louisiana, Lafayette, South Texas, and Southeastern chapters.

★ ★ ★

Nevada Boom

Though the Shell Eagle Springs No. 1 continues to be the sole encouraging development in the state, there has been little abatement in the demand for leases and the acquisition of drilling rights continues on a high level. Shell has not completed its apparently successful test. After recovering heavy black oil at a 180 bbl rate from 6453 to 6533, operators have drilled below 9200 with no more shows. Meanwhile Gulf has plugged two tests, one to 4498, the other to 8412, and has two more drilling. California Standard with extensive holdings is currently confining exploration to seismic studies.

★ ★ ★

Dallas Firm Expanding

Oil and Gas Property Management, Inc., has purchased from Floyd L. Karsten and Associates, approximately 150 oil, gas, and condensate wells on 11,800 acres of land located in 31 separate fields in Texas, Louisiana, and New Mexico.

Daily production involved in the transaction approximates 5000 bbl of oil and condensate and 30,000,000 cu ft of gas production. Included also in the transaction is approximately 10,000 acres of non-producing leases, various drilling rigs, workover equipment, gathering oil and gas pipe line systems, compressor stations, and dehydration plants.

★ ★ ★

Canadian Development

Canada's rate of oil development continues to rise with reserves, production, refining, and consumption heading for new peaks. Canada has moved from 17 to 7 among the world's oil producing nations since 1947. In 1953 crude oil reserves reached 3 billion barrels — a 50 per cent increase over 1952; natural gas reserves increased from 10½ trillion cubic feet to 14½ trillion cubic feet; oil production increased by 33 per cent for a new record of 81,000,000 bbl, and over $1,000,000 per day went into exploration and development in Western Canada.

★ ★ ★

Levelland Unit

Climaxing more than six years of negotiations, the Levelland, Texas field unit has been approved by the Texas Railroad Commission. Unit operations have begun, with Stanolind Oil and Gas Company as the operator. Eligible unit area includes 16,000 proved acres and 378 producing oil wells. The unit was formed in the interest of promoting conservation and preventing waste of petroleum hydrocarbons. A substantial increase in the recovery of crude oil from the Levelland reservoir is expected as a result of the unitization project and a gas injection secondary recovery program to be initiated soon.

★ ★ ★

Magnolia Scholarships

Texas A and M. College has selected for one of seventeen Magnolia Petroleum Company scholarships for the year 1954-55. This scholarship results from a policy of the company to encourage, assist, and recognize outstanding students in the fields related to geology, geophysics, and petroleum engineering. The award will be worth $750.

★ ★ ★

Cuban Wildcat

Indications of commercial production in Central Cuba were had with the flowing test of a 1050-1000 ft zone encountered in an 8375 ft wildcat drilled southeast of Havana. Located in a large sedimentary basin, the strike is of great significance since it confirms oil production in this large section of the island. Cuba currently imports most of its 50,000 bbl per day requirements.

★ ★ ★

French Production

Discovery of production in Southern France, 100 miles southwest of Bordeaux, is announced. The SAF No. 1 Panetis tested 1100 bbl on a ¼-in. choke, 33 deg low sulfur crude, from 7415 to 7431 ft. Further drilling indicated approximately a hundred foot oil column. Well is drilling deeper.

SINGLE ZONE

or DUAL ZONE

production with ONE

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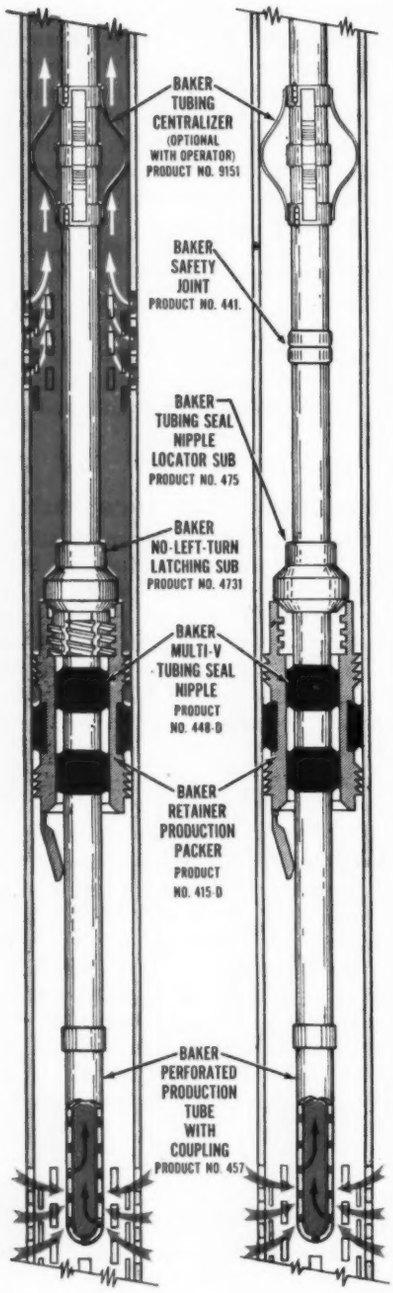
RETAINER
PRODUCTION PACKER


BAKER TUBING CENTRALIZER (OPTIONAL WITH OPERATOR) PRODUCT NO. 9151
BAKER SAFETY JOINT PRODUCT NO. 441
BAKER TUBING SEAL NIPPLE LOCATOR SUB PRODUCT NO. 475
BAKER NO-LEFT-TURN LATCHING SUB PRODUCT NO. 4731
BAKER MULTI-V TUBING SEAL NIPPLE PRODUCT NO. 448-D
BAKER RETAINER PRODUCTION PACKER PRODUCT NO. 415-D
BAKER PERFORATED PRODUCTION TUBE WITH COUPLING PRODUCT NO. 457

Typical Dual Zone Hookup

Typical Single Zone Hookup

Do you know that with only ONE Baker Retainer Production Packer you can equip your well for *either* SINGLE ZONE or DUAL ZONE production? And that you can accomplish *any* type of completion for *any* method of production to meet *fixed* or *changing* well conditions?

A single Baker Retainer Production Packer will also outperform many specialized tools when used as a TESTING PACKER – SQUEEZE PACKER – GAS LIFT PACKER – PERMANENT COMPLETION PACKER – WATER FLOOD PACKER – GAS INJECTION PACKER – CORROSION CONTROL PACKER – TUBING ANCHOR – ONE-WAY BRIDGE PLUG – PERMANENT BRIDGE PLUG.

Every production man should be familiar with the many operating advantages of this "Universal Type" Packer, which include . . .

WIRE LINE SETTING—The packer can be set with *wire line speed and accuracy,* using the same set-up just used for perforating. The Baker Packer also can be set on drill pipe or tubing.

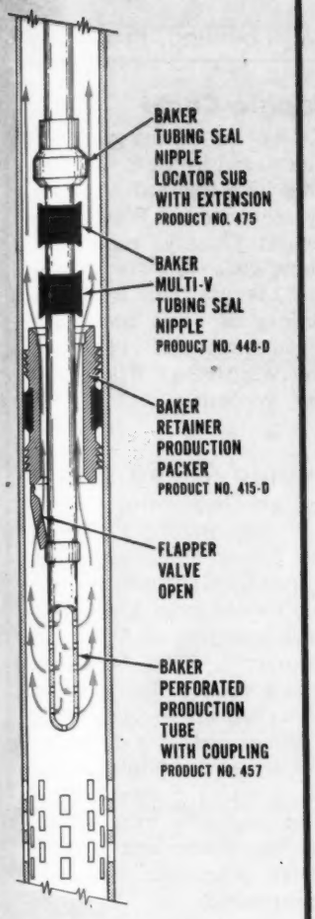
SETTING UNDER HIGH PRESSURE—By using a lubricator, the Baker Retainer Production Packer can be set under high pressure. From the moment it is set, the self-contained, flapper-type, back-pressure valve closes and isolates pressure below the packer.

TUBING STRING IS ALWAYS "FREE"—That valuable string of tubing—whether 1,000 feet or 16,000 feet in length—can be removed by simply picking up the tubing weight.

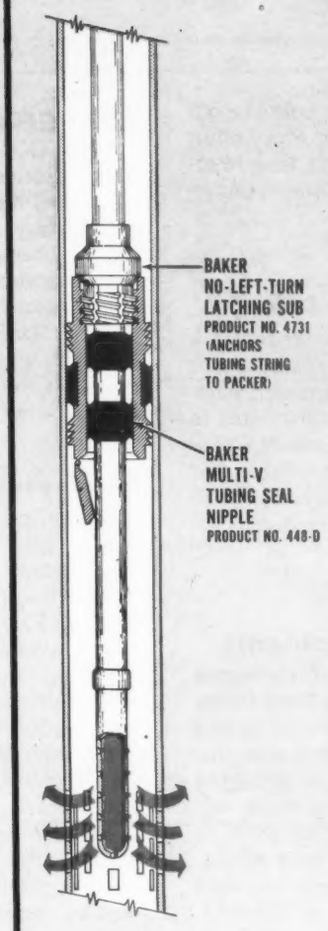
EXCESSIVE "SET-DOWN" WEIGHT OR TENSION NOT REQUIRED—Even when squeezing, formation fracturing, or producing at any depth under pressure, a perfect pack-off is maintained independent of excessive set-down weight, or tension.

HOLDS PRESSURE DIFFERENTIALS FROM ABOVE OR BELOW—Two sets of opposed slips, and a resilient packing confined by lead and metallic sealing rings, effect a permanent pack-off that will hold any pressure differential *either from above or below the packer* that is safe for the well equipment.

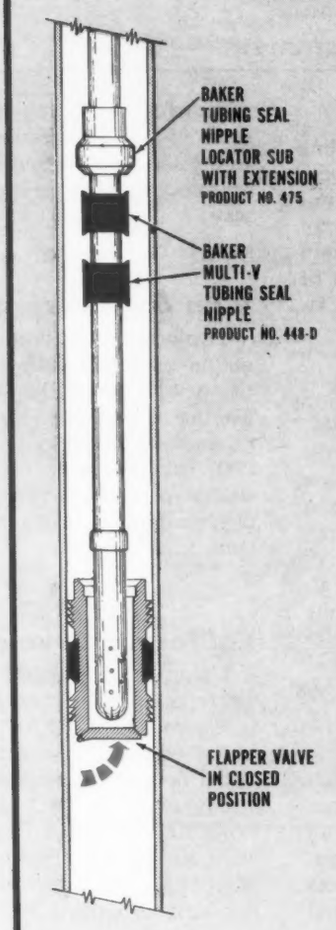
PACKS-OFF AND HOLDS UNDER HIGH BHT—Baker Retainer Production Packers will hold high pressures under conditions of high temperatures. Hundreds of Baker Packers are in successful service in Southwest and Gulf Coast areas where temperatures in excess of 300 degrees are not uncommon.



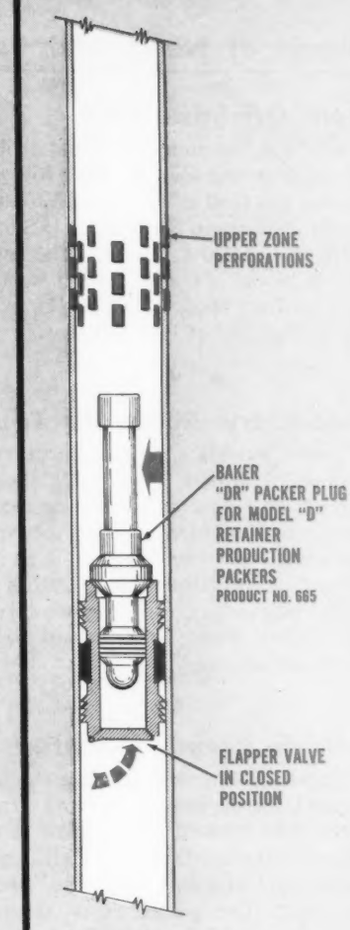
Washing or Circulating Tubing Seal Nipples removed from packer bore. Flapper Valve held open by tubing extending below Tubing Seal Nipples.



Pressuring Below Packer Acid or cement squeeze, formation fracture, gas or water injection. Latch Sub used when squeeze pressures exceed tubing weight.



Isolate Zone Below Packer Tubing String removed, Flapper Valve closed. Isolates pressure differentials (squeeze, productions) from below the packer.



Temporary Bridge Plug For working over zones above packer. DR Plug run in on Baker Retrievable Cementer, and retrieved with overshot. *Permanent Bridge Plug* can be formed with Trip Bob (not illustrated).

RESISTS CORROSION —The cast-iron used in the construction of Baker Packers is far more resistant to corrosion than the casing in which the packer is set, thus making it ideal for permanent installations, or for use in areas plagued with a severe corrosion problem.

EASILY DRILLABLE —The Baker Packer is constructed of drillable cast-iron, and its design supplements the breaking-up action of the bit. Whether it has been in the well for only a few hours, or for ten years, the Baker Packer can be drilled up in minimum time. Expensive and hazardous "milling-out" operations never are required.

IMPORTANT FACTS

Baker Packers are used in a majority of installations where conditions of extreme pressure, temperature, or depth are present. Baker Packers also dominate Dual Zone installations, particularly those involving two-packer, crossed-flow arrangements.

BUT IT IS ALSO TRUE that *more* Baker Packers are used for *simple single zone* completions than for *any other type of completion,* and that *most* Baker Dual Zone installations employ *only one* packer.

Ask any Baker representative, or office, for complete details, as well as your copy of the recent Baker Equipment News dealing with DUAL ZONE COMPLETION PRACTICES. There is no charge, and no obligation, for specific recommendations and completion planning advice available from Baker Technical Advisers. Why not be prepared for your next completion?

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IF YOUR WELL IS WORTH COMPLETING,
it's WORTH COMPLETING WELL,
with a

BAKER

RETAINER PRODUCTION PACKER

Gulf Offshore Test

Gulf Oil has announced that drilling of the first test well on its 5760-acre lease in the Gulf of Mexico, off Corpus Christi, will begin about June 1. Site of the well is 6000 ft north of the south line of block 774 and 3500 ft west of the east line, approximately 8½ miles south-southeast of Port Aransas.

★ ★ ★

Secondary Recovery Tour

Under guidance of the Bartlesville Bureau of Mines, Kansas-Oklahoma water flood operators have completed a successful tour of secondary recovery operations in the Burbank area of Osage County. Some 350 operators attended the study, an annual spring event in the water flood area of Oklahoma and Kansas.

★ ★ ★

Turkish Permit Granted

American Overseas Petroleum has received an exploration permit from the Turkish Government. Firm is an affiliate of Standard of California, California Company, and The Texas Company. The permit was granted under the newly denationalized petroleum resources law and was preceded by extensive geological surveys.

★ ★ ★

Louisiana Lets Lease

Sinclair, with a record bonus in excess of three million dollars, has been awarded a 2018 acre lease off Timbalier Bay, site of extensive production developed by Gulf. Gulf, California Company, Texas Company, and Shell were unsuccessful bidders. The State Mineral Board leased in all, 16,054 acres for an average bonus of $345 per acre.

★ ★ ★

Pacific Coast API

C. F. Gates, General Petroleum Corporation, has been elected chairman of the Pacific Coast district of the API's Division of Production. Gates succeeds Milan G. Arthur, Union of California.

Vice chairmen elected were: E. M. Benson, Jr., Richfield Oil; Hugh C. Mays, Crescent Petroleum; John Van Riper, Continental, and Jack Lemley, Standard Oil.

★ ★ ★

New Mexico Blowout

Continental has successfully plugged its wild well in Lea County, after fighting fire and blowing oil and gas for almost two months. The company used 3200 bbl of mud and over 5000 sacks of cement in plugging the hole. An offset well is in progress and every effort to tap the indicated prolific lime reservoir uncovered in the lost hole is underway.

★ ★ ★

Plan Engineering Lab

Exploration and production research on an extensive scale is planned for the new Imperial Oil petroleum engineering laboratory to be constructed in Calgary. Expected to cost nearly $400,000, facilities will be available for studies of reservoir engineering, geology, geophysics, and production problems.

★ ★ ★

California Developments

Union Oil Company of California has reported completion in Kern County, California, of its fifth producing well in the North Guijarral Hills area, for initial flowing production of 1800 bbl a day of clean 38.2 deg crude oil. Producing from the interval 8696 to 8873 ft, well was flowing on a 40/64-in. choke when tested. This is the most northerly producing well in the field.

Stratigraphic Chart

Chart OC49 of the oil and gas investigation series issued by U. S. Geological Survey has been released. Covering sedimentary sequences in Wind River Basin, Fremont County, report describes sections whose total thickness is in excess of 52,000 ft. Title is "Stratigraphic Sections of Cody Shale and Younger Cretaceous and Paleocene Rocks in the Wind River Basin, Fremont County, Wyoming."

★ ★ ★

Pennsylvania Crude Cut

Notice of another reduction in posted price for Bradford district Pennsylvania Grade crude has been made. This cut brings the posted price down to $3.00 a bbl from $3.76, and reflects a total reduction of $1.05 per bbl since January 1, 1954. While no reason for the reduction was given, it is fairly obvious that the lessened value of this high grade crude is a direct result of improvement in refining technique, which permits the manufacture of high grade lubricants from mixed and asphaltic base crude. Price reduction may force premature abandonment as uneconomical.

How to

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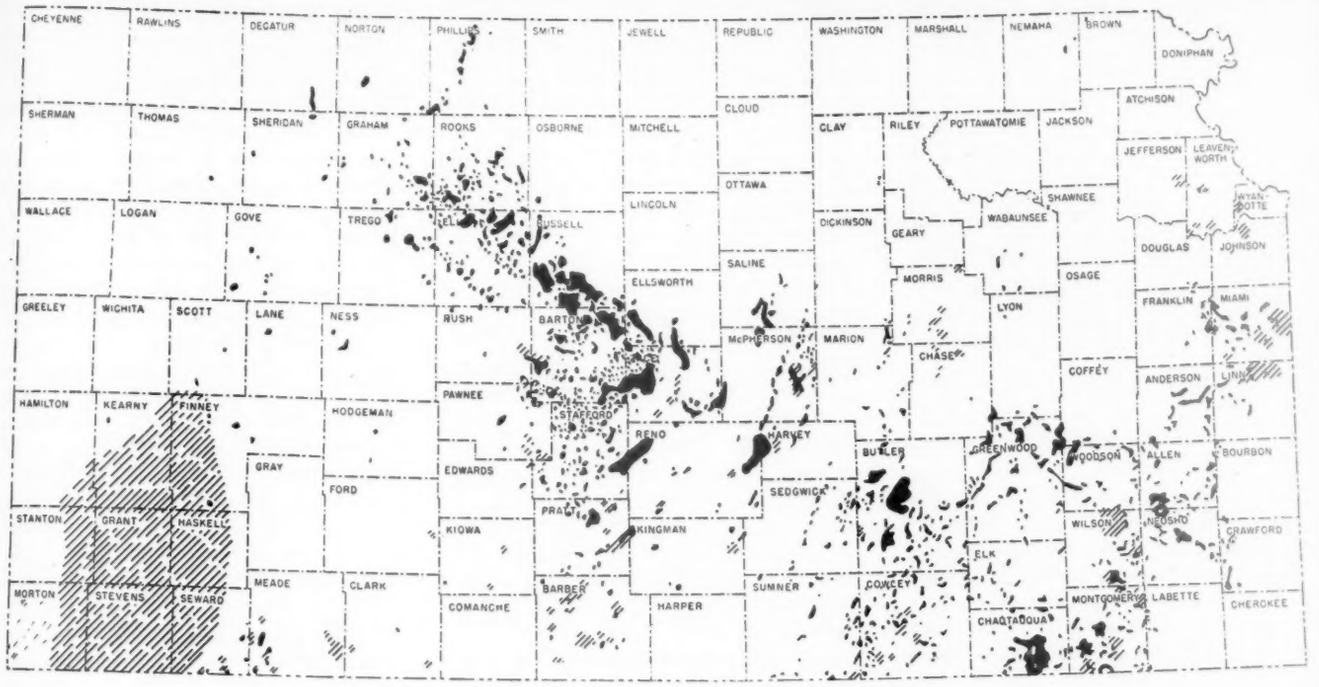

FIG.1. Map of Kansas showing distribution of oil and gas fields.

Kansas Oil Potential High After 100 Years

First oil well in this area of Mid-Continent was drilled in 1860, and the state still ranks fifth in the United States as an oil and gas producer

J. M. JEWETT

KANSAS has been one of the half dozen or fewer top-ranking oil states since the beginning of the American petroleum industry. Now in fifth position as a producer of both oil and gas, Kansas has placed as high as third. In years of production it is second only to Pennsylvania. As Pennsylvania's volume of output has been lagging for many years, Kansas for a long time has been senior member of the "Big Six." The state has not held, however, even temporarily, first place in volume of production. Leadership in the number of barrels of oil taken from the earth each year has for some time belonged to Texas, which surpasses any other state in production by a margin as great as its surface exceeds that of smaller states.

The 1953 Kansas production of hydrocarbons was: Crude oil, 114,390,176 bbl; natural gas (at a pressure base of 14.65 psia), 420,588,383 thousand cubic feet; natural gas liquids, 5,039,444 bbl. The value of crude oil, natural gas, and natural gas liquids amounted to approximately $360,000,000.

These products came from oil and gas fields covering a large part of the Sunflower state, as shown in Fig. 1. The number of new fields opened in 1952 was 167 and in 1953, 187. Including new producing zones in old fields, the number of actual pool discoveries has greatly enlarged the number of new fields added. In fact pool discoveries in Kansas in 1953 amounted to 250. The number of oil fields opened in Kansas in each of the last 10 years are shown graphically in Fig. 2.

The Author

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EXCLUSIVE

Nearly 100 Years of Oil

First oil well in Kansas was drilled in 1860. It was near Paola in Miami County, about 45 miles south of Kansas City. Thus oil was found in "Bleeding Kansas" — the year before the

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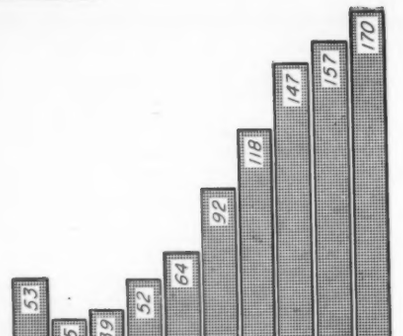


FIG. 2. Graph showing numbers of oil fields opened in Kansas each year during the period 1944-1953.

state entered the Union, in the first year of the Civil War, and less than a year after the famous Drake well in Pennsylvania had started the oil industry in North America.

First 50 years. In 1910, a half century after the discovery well, Kansas produced approximately 2 million barrels of oil. Even though annual production had dropped considerably since 1904, there were many shallow oil and gas fields in the country to the south and west of Paola, there were refineries in several towns, and cheap natural gas had led to the establishment of various industries in southern Kansas. There were Portland cement plants, lead and zinc smelters, brick and tile plants, and glass factories. Conditions still seemed prosperous, but they were not altogether promising. Insufficient supplies of natural gas were in sight and the expectation of finding but a few new oil pools was practically nil.

Except for some known gas-bearing Permian beds in east-central Kansas, strata that were yielding oil and gas 40 years ago are found only in the lower part of the Pennsylvanian rock section, the "Coal Measures" of the times. Top of Mississippian limestone beds, which unconformably underlie the Pennsylvanian in eastern Kansas, was believed without doubt to mark the lower limit of possible commercial accumulations of oil and gas. Some wells had been drilled deeper but no production had been found in pre-Pennsylvanian rocks.

It was held that to drill below the top of the "Mississippi lime" was useless.

The nearly uniform westward dip of the outcropping rocks that had been observed in eastern and central Kansas signified a steadily increasing depth to possible oil and gas-bearing zones in Pennsylvanian rocks in the western part of the state. Depths were believed to be beyond drilling possibilities and it was reasonable to expect the occurrence of salt water in any deeply buried strata farther west than the oil fields of those times.

So for many years the eastern Kansas area continued to be the only known oil province in the state. Chanute in Neosho County was the oil capital of Kansas and Neodesha (Wilson County) and Coffeyville and Independence (Montgomery County) were well-known oil towns. But conditions were to change. El Dorado, Augusta, Russell, Wichita, Hays, Great Bend, Ellinwood, Liberal, Hugoton, and other towns in central and western Kansas were to be transformed because of the unsuspected oil and gas that lay beneath the plains. The years 1914 and 1923 were to be the most eventful.

Discovery of Nemaha Anticline

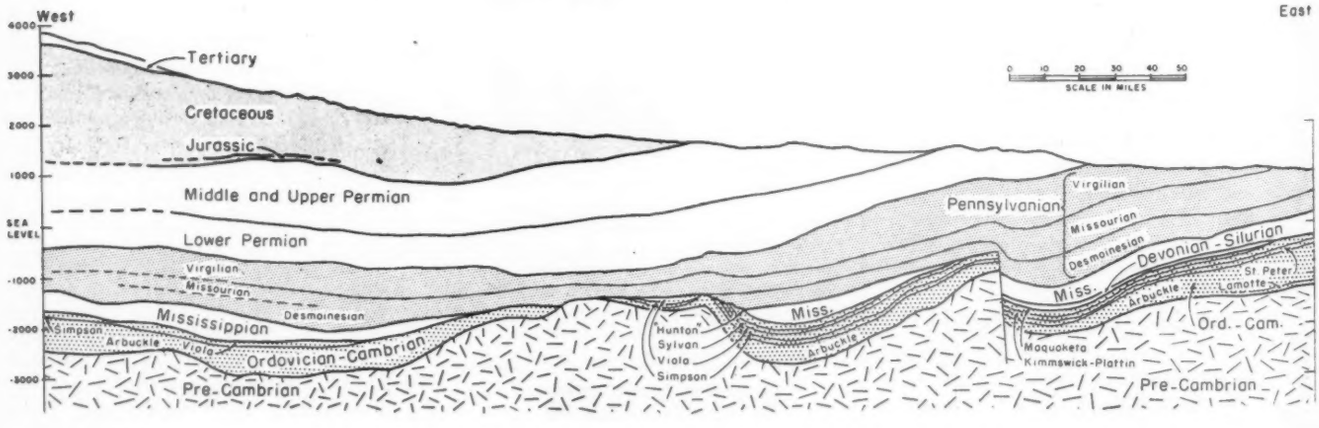
A geologic section, east to west, across Kansas is shown in Fig. 3. Conditions shown are not at all as were suspected before about 1914 or even 1923. Instead of continued westward dip of Permian, Pennsylvanian, and lower beds, the monoclinal structure is interrupted by the Nemaha and Barton uplifts, thus bringing rocks equivalent to the oil and gas-bearing beds of the eastern part of the state into the range of relatively shallow drilling and allowing for traps that contain pools far larger than were known in the early days.

It was after 1914 and 1915 when oil and gas were found in the Augusta and El Dorado fields, about 30 miles east of Wichita, that really important oil and gas production began in Kansas. Henceforth oil output was to be measured in tens of millions of barrels and gas in tens of billions of cubic feet. Discovery wells were located on the basis of geological surface mapping that showed the presence of a relatively prominent anticline extending to the east of north. The trend was traceable into Nebraska and drilling soon revealed subsurface conditions entirely different from what had been supposed.

Mississippian and Ordovician rocks were found at relatively shallow depths, locally less than 3000 ft, and large quantities of oil and gas were found in these pre-Pennsylvanian rocks. Production was obtained also from Pennsylvanian rocks in some areas but the discovery of abundant oil and gas in the condemned pre-Pennsylvanian strata and the acquisition of evidence calling for drastic revision of the picture of subsurface structure in central Kansas are the significant revelations that make the opening of the El Dorado field a very important landmark. Wells drilled north of El Dorado found granite from less than 1000 to about 3000 ft and in some wells Pennsylvanian beds were found to lie on crystalline rocks. Before long it became clear that these crystalline rocks are a part of the Pre-Cambrian floor on which lie all the stratified sedimentary formations. The crystalline rocks are elevated in a ridge and the name "Nemaha mountains" or "Nemaha granite ridge" came into common usage.

At El Dorado most of the production for the first two years was from late Pennsylvanian and early Permian rocks at a depth of about 600 ft, but the Ordovician "Stapleton" pay zone had been found in the discovery well, which by the way is again producing

FIG. 3. East-west geologic cross section through central Kansas.



from the "600-ft sand." It was the "Stapleton" zone, source of many great gushers, that made El Dorado famous and upset the oil market of the world. The "Stapleton" is a zone of beveled Viola, Simpson, and Arbuckle beds, below the disconformity at the base of Pennsylvanian rocks there. At first it was believed to be a zone at the top of Mississippian limestone, but R. C. Moore and A. E. Fath, whose geologic thinking was in advance of the time, suspected the true interpretation.

Sensational developments at El Dorado were followed almost immediately by similar discoveries at Augusta. There the chief pay zone, at about 2500 ft, was called the "Varner," but it is now known to be in beveled Viola and Simpson beds, below the disconformity at the base of Pennsylvanian rocks and comparable to the "Stapleton."

Tests on prominent "domes" along the crest of the Nemaha anticline north of El Dorado were disappointing, except for modest quantities of gas in Permian and Pennsylvanian rocks. Ordovician rocks are not present on these domes, and it may be said that some of the "saddles" might still be tested with success. Exploration along the southern trend of the anticline in Kansas and in several areas on the west flank resulted in new fields of importance in Cowley, McPherson, Harvey, and Sedgwick counties. Drilling in Greenwood County, east of the anticline, resulted in discovery of the rich "Golden Lanes" oil fields that follow strong northeast and in part southeast trends. These trends are now known to mark the courses of long, narrow "shoestrings" in the lower Pennsylvanian section, the origin of which was indirectly controlled by the near-by "granite ridge." Without the impetus of drilling that came from the success at El Dorado and Augusta the exploration of Greenwood County and the area west of El Dorado probably would have been long delayed.

1923—Oil in Western Kansas

Although oil had been found as far west as the Walton field, Harvey County, in 1919, little was expected of western Kansas until the discovery of oil in the "Oswald lime" (Pennsylvanian) in the Fairport anticline, in Russell County, in 1923. The anticline was mapped in outcropping Cretaceous chalky limestone and seemingly few geologists and oil men believed that the test well would be a producer. The initial production of the No. 1 Oswald was 200 bbl of 38 gravity oil coming from Pennsylvanian rocks at a depth of 2900 ft. The importance of this discovery and the subsequent development of Fairport anticline is not measured by the quantities of oil obtained, even though they have amounted to many millions of barrels. The significance of the early operations in Russell County lies in the great incentive that was given to explorations in other western areas. The many wells that were drilled have furnished a great deal of valuable geological information. The presence of Ordovician rocks at unexpectedly shallow depths was proved in a large northwest-trending area — the Barton arch. In some parts of the uplift Pennsylvanian sediments lie on the Pre-Cambrian as is the case throughout most of the northern part of the Nemaha anticline.

On the Barton arch and in neighboring area oil is produced not only from Pennsylvanian rocks, but in Mississippian, Ordovician, and even in Pre-Cambrian rocks. Thus in the 1920's western Kansas stole the show and in the late 30's, because of western Kansas' production, the state's annual production reached 70,000,000 bbl of oil.

Hugoton Gas

Outside of the Hugoton area, western Kansas has produced and still is producing large quantities of natural gas, and eastern Kansas was an important gas-producing area years ago. Nevertheless it is the great Hugoton field in the southwest part of Kansas that makes her one of the five great gas-producing states. The Hugoton area lies above the northern part of the world's largest known gas pool. The Kansas part of the pool contains proved reserves amounting to more than 14 trillion cubic feet, which amount is more than half of the pool's total. In this general area, gas was found in Seward County, in the Liberal pool, as early as 1922. The discovery well was rated at 5,000,000 cu ft of gas per day and is said to have drawn some attention to Permian gas possibilities in the area. It was not until 1927, however, that the first gas well was drilled in the Hugoton field as it is now defined. The well is near Hugoton, Stevens County, and it was rated at 6,000,000 cu ft per day. Still the field was developed very slowly; in 1942 real interest in the great quantity of gas became general. Now the area has become of some importance also because of oil that has been found in Pennsylvanian rocks.

1949 — New Interest in Eastern Kansas

In reviewing the highlights of discoveries and developments some mention should be made of the discovery of the Davis Ranch oil pool in Ordovician rocks, in Wabaunsee County, early in 1949. For a time somewhat feverish activity returned to a part of eastern Kansas. The Davis Ranch field, only a few miles east of the Nemaha anticline, is in a broad synclinal area parallel to the anticline. Because of its synclinal nature, this area had been shunned earlier when the Forest City basin was somewhat generally explored. The pool is in a local structure that was mapped in outcropping Permian rocks. Several small pools were found along the same trend from Lyon County, in central Kansas, to Nemaha County on the state's northern boundary. These pools are in local anticlines within the broad syncline and production has come from "Hunton" (Devonian) as well as Viola and Simpson (Ordovician) rocks. Although production in the trough east of the Nemaha uplift has not been particularly sensational, the discoveries there, so many years after the territory had been passed by, comprise a noteworthy event.

Re-evaluation of eastern Kansas for deeper production has resulted in several new Mississippian and Ordovician fields and even Pennsylvanian pools have been found in rather amazing numbers during the last few years. In reviewing, secondary recovery, which began in shallow eastern Kansas fields years ago, should not be overlooked. Water flooding has maintained eastern Kansas' output and even increased it. It is now spreading into western Kansas fields. Production attributed to secondary recovery, chiefly water flooding, in 1953 amounted to approximately 10,400,000 bbl of oil. Within the last few years formation fracturing has greatly stepped up activity in eastern Kansas. Areas formerly regarded as sub-marginal have been brought into production. New fields are possible where a few years ago there were only abandoned holes with "shows." The old eastern stripper area may be said to be approaching flush production again.

Oil and Gas-Bearing Rocks

For convenience one may divide the rocks in Kansas into seven main structural categories, defined in part by the nature of the rocks themselves and partly by their age differences, but mainly by their structural distinction each from the other. Of these seven divisions, four — Pleistocene-Tertiary, Cretaceous, Permian-Pennsylvanian, and Mississippian — can be seen at outcrops. The other three, Devonian-Silurian, Ordovician-Cambrian, and Pre-Cambrian, are known only through well cuttings. A brief summary of the seven divisions follows. Fig. 5 shows a series of generalized sections, representative of various parts of the state. Locations of the columnar sections are shown in Fig. 4.

Pleistocene-Tertiary. Pleistocene deposits in Kansas, almost without exception, are unconsolidated. They com-

prise alluvium and terrace deposits along stream valleys, wide-spread blankets of loess, and in northeastern Kansas glacial till and outwash. In many places these surficial sediments conceal the tectonic structures in the underlying bedrock. Locally the thickness of Pleistocene deposits is as much as 500 ft but in general it is much less. Tertiary beds, wide spread in western Kansas but largely covered with loess or other Pleistocene accumulations, also blanket older strata and hide their structural features. They too are in part unconsolidated, but in part are well cemented and even quartzitic. The maximum thickness of Tertiary deposits is about 400 ft. In eastern Kansas chert gravels, high on the present divides, are believed to be stream deposits that were laid down in late Tertiary time. The history of Pleistocene rocks in Kansas has been made known largely through the studies of John C. Frye.

Cretaceous Rocks. Cretaceous rocks are set apart structurally from older rocks, because they lie unconformably on older Mesozoics in parts of western Kansas, and on various horizons of the Permian. North of Kansas they overstep older rocks and overlap onto the Pre-Cambrian. They are spread across all the western part of the state and extend as far eastward as Marshall and Riley counties. Cretaceous rocks are thickest in the northwestern part of the state, where wells have penetrated more than 6000 ft. These rocks comprise brown, ferruginous sandstones, dark-colored clayey shales, and chalky limestones. Nowhere in the state are Cretaceous rocks known to contain oil, but moderate quantities of gas have been obtained in Sherman County.

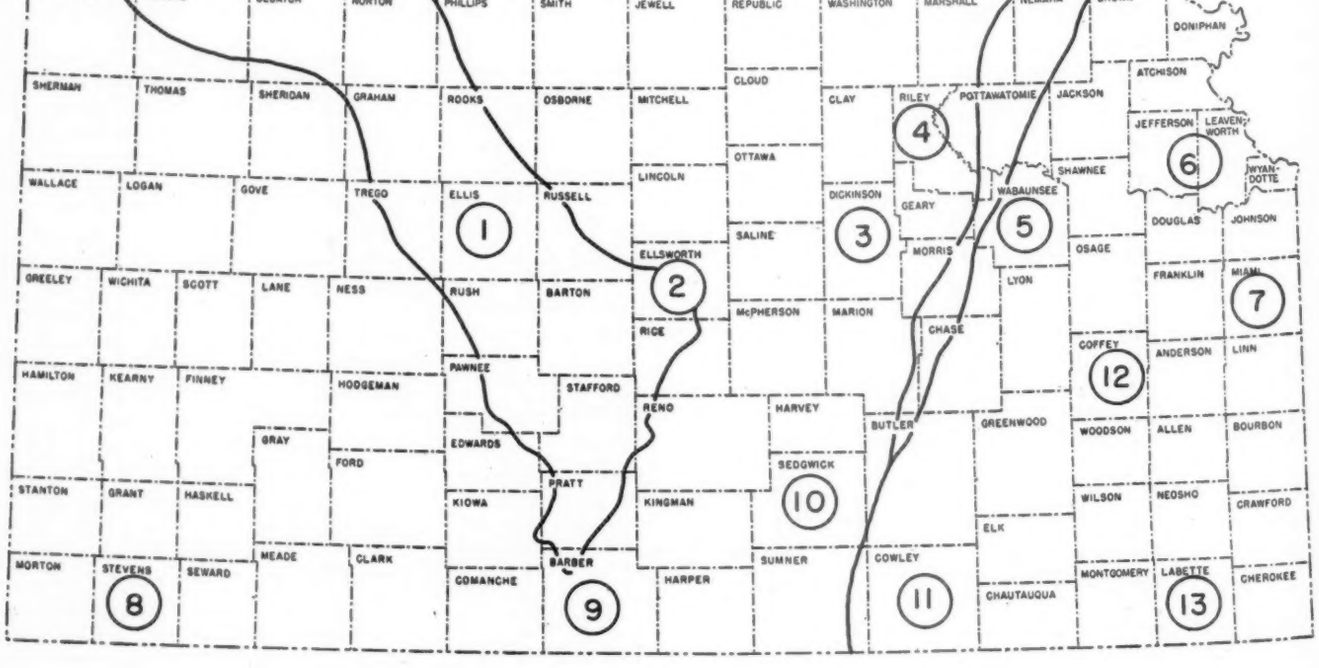
Permian-Pennsylvanian. Because of the lack of evidence of disconformity, except very locally, between Permian and Pennsylvanian rocks in the northern Mid-Continent region, it is convenient to discuss rocks of the two systems as a single structural unit. They are much older than the overlying Cretaceous beds and are separated from them by an important unconformity. Likewise they are separated unconformably from Mississippian and older rocks. Hence these upper Paleozoic formations comprise a distinct structural unit. These rocks range in thickness from a fraction of a foot, along the eastern margin of their outcrop area, to more than 6000 ft in the southern part of the Kansas part of the Hugoton embayment, in southwest Kansas. They are exposed in east-central and eastern Kansas, where they dip westward at a low angle. Many limestones are excellent key beds for structural mapping.

Little oil, perhaps less than one per cent of the state's annual production, comes from lower Permian rocks. Permian formations that crop out in east-central Kansas, however, and which are buried under younger deposits farther west, are by far the most important source of gas in the state. The great Hugoton gas pool, which contains some 95 per cent of the state's proved gas reserve and the largest known gas pool in the world, in a lower Permian reservoir. More than 90 per cent of the state's current gas production comes from Permian rocks, chiefly in the Hugoton field and partly from other Permian pools. The Hugoton gas field occupies nearly 5000 sq miles in Kansas. To the end of 1953, 3214 gas wells had been drilled in the area. Of these, 3101 are now producing gas. The 1953 production amounted to 387,635,243 thousand cubic feet. The proved reserves stand at 14.05 trillion cubic feet.

Pennsylvanian rocks are present everywhere in Kansas except in an area of about 50 sq miles in the southeast corner of the state. Maximum thickness is in the Hugoton embayment area where a thickness of about 2600 ft has been recorded. There the earliest known Pennsylvanian rocks in the state are present. Minimum thickness is immediately west of the eastern margin of the outcrop belt, east of which are Mississippian limestone outcrops. With the exception of the lower part of the Pennsylvanian section in the Hugoton embayment, all known Pennsylvanian rocks in Kansas belong to the middle and upper divisions of the system.

Pennsylvanian rocks, for many years the sole source of Kansas oil production, are by no means without significance in the present total oil output. More than 20 per cent of the current yield comes from these rocks. In central and western Kansas beds in the Wabaunsee, Lansing, and Kansas City groups are important reservoir rocks. Porosity in limestone, especially in open-textured oolitic zones, is especially characteristic of the Lansing-

FIG. 4. Outline map of Kansas showing locations of representative columnar sections.



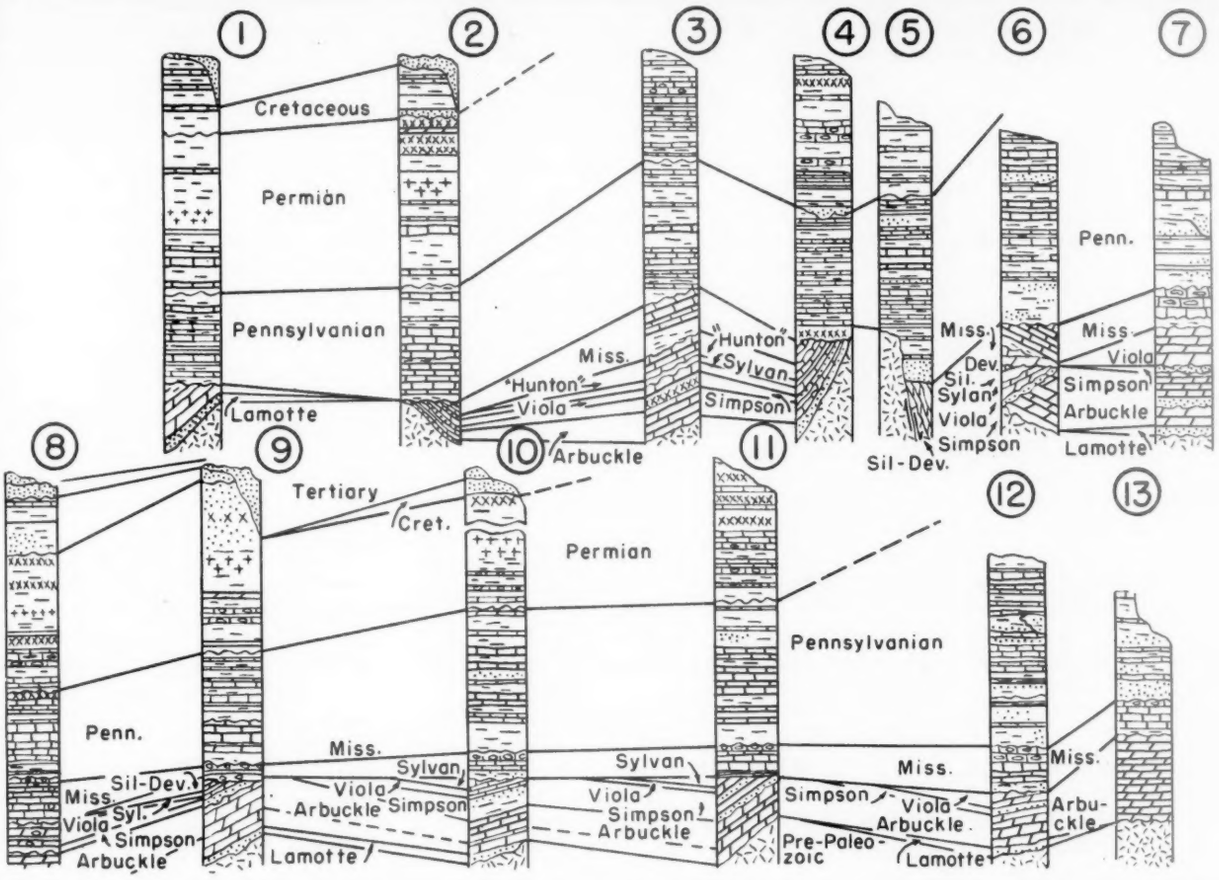


FIG. 5. Columnar sections showing thickness and general nature of rocks in oil- and gas-producing areas in Kansas. Locations of the sections are indicated in Fig. 4.

Kansas City production in many fields scattered widely in central Kansas. In eastern parts sandstones, especially in the lower part of the Pennsylvanian section, are the chief producing zones. Lenticular sand bodies, many of the "shoestring" type, afford stratigraphic traps. In several counties structural control in more sheetlike sand bodies is important.

Mississippian Rocks. A very small part of southeasternmost Kansas contains outcrops of lower Mississippian rocks and strata of this age are widely exposed in neighboring areas. These constitute a fourth stratigraphic-structural main rock division of Kansas. They are characterized by the dominantly limestone nature of the deposits and they are set apart structurally by prominent unconformities at the top and base. Most information about Mississippian rocks in Kansas has been obtained from well data and has been made known especially through the work of Wallace Lee, geologist for State Geological Survey.

Maximum thickness of Mississippian rocks in Kansas is in the southwest part where more than 1000 ft has been found. In most of the state the original thickness was reduced greatly by erosion before burial. The absence of Mississippian rocks in the Barton arch and Nemaha uplift areas may be in part the result of nondeposition and certainly in part the result of erosion before the time of Pennsylvanian sedimentation.

In many places there is a deposit of chert and clay, called "chat," on the limestone surface. The "chat," an important source of oil in many fields, probably chiefly accumulated in Pennsylvanian time, but inasmuch as it is largely debris of Mississippian rocks it is known as "Mississippian chat." The limestones as well as the "chat" are important reservoir rocks. Production, where found, generally but not everywhere is from the upper parts of the highest formation present in the area. In parts of Kansas the term "first break" designates a porous zone not many feet below the top of Mississippian rocks.

Underlying the Mississippian limestones in most parts of the state is the Chattanooga shale, which may be at least in part of Devonian age. This is chiefly spore-bearing black, gray, or greenish shale, but locally grades into dolomitic limestone or sandstone. In places the "Misener" sandstone separates the Chattanooga from the overlying Mississippian limestone. The "Misener" is believed to be of Kinderhookian (early Mississippian) age.

Something like 10 per cent of Kansas oil comes from Mississippian rocks. The percentage of cumulative production from these rocks, is higher.

Devonian and Silurian Rocks ("Hunton" Limestone). Devonian and Silurian rocks in Kansas commonly are referred to as the "Hunton" limestone, but in recent years rocks of these systems, which chiefly are limestones and dolomites, have been differentiated and correlations with formations cropping out in other states have been made. The Devonian and Silurian rocks are separated from each other by an angular unconformity and the unit is separated from overlying and underlying rocks by important unconformities. Commonly their structural attitude, however, is more nearly in accordance with the underlying Ordovician than with the Mississippian beds.

In Kansas these rocks are known to be present in the Forest City, Salina, and Sedgwick basins. They possibly are present in the Hugoton embayment. Currently "Hunton" limestone production amounts to about 5 per cent or more of the state's oil output. Prolific fields that produce from this unit principally are in the Sedgwick basin.

Ordovician-Cambrian Rocks. All

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Paleozoic rocks below the Silurian and down to the great unconformity at the top of the Pre-Cambrian constitute a sixth rock division. Strata of this division consist chiefly of dolomite and some sandstone of Ordovician and Cambrian age. Well-known subdivisions (descending) are Sylvan (Maquoketa) shale, Viola (Galena or Kimmswick) limestone or dolomite, Simpson formation (including the St. Peter sandstone), the Arbuckle "siliceous lime" group, Bonneterre dolomite, and the Reagan (Lamotte) sandstone. Combined thickness of these rocks is as much as 1500 ft. In many places because of retarded rate of deposition, non-deposition, or erosion, however, the thickness is much less. The Viola and Simpson are prolific sources of oil in many fields, but the largest producer is porous rocks in the Arbuckle group. The Bonneterre and Reagan also contain oil pools. The Ordovician-Cambrian division has yielded considerably more than half of the oil that has been produced in Kansas, and is yielding more than half of the current production.

Pre-Cambrian Rocks. Many wells in Kansas have been drilled completely through the Paleozoic rocks into the more crystalline basement rocks. Some early wells were continued to a considerable footage into granite or metamorphic rocks because it was not recognized that these rocks are Pre-Cambrian and are generally believed not to contain oil or gas.

A relatively small amount of oil and gas is produced from Pre-Cambrian arkose and weathered quartzite in Barton, Rice, and Russell counties. The oil and gas there occur in stratigraphic traps in metamorphic rocks lying below sediments of Pennsylvanian age.

As almost everywhere, in Kansas the upper surface of Pre-Cambrian rocks constitutes the most irregular geologic datum. In the Hugoton embayment these rocks lie 5000 ft or more below sea level; in the northern part of the Nemaha anticline the "granite ridge" is slightly more than 500 ft above sea level. In eastern Kansas, east of the Nemaha anticline, these basement rocks generally slope gently to the west. They are less than 1000 ft below sea level in southeastern Kansas and in Brown County, a few miles east of their greatest elevation in the Nemaha uplift, they are 2500 ft or more below sea level. In an area in Cowley County, in southern Kansas and also east of the Nemaha anticline, they are at about the same level as in Brown County. Along the crest of the anticline itself the granite slopes to a position of more than 2500 ft below sea level in northeastern Sumner County. In the Barton arch area Pre-Cambrian rocks occur at about 600 ft below sea level.

Structural Provinces

Because of the thousands of wells that have been drilled the general nature of the distribution, thickness, and structural arrangement of the buried rocks in most parts of Kansas are known. Structural provinces must be thought of in relation to time; otherwise one does not gain a clear understanding. This may be explained by noting that some areas of ancient uplifts later became basins and *vice versa*. For example, in middle Pennsylvanian time a shallow depositional basin extended into southeastern Kansas; we speak of it as the Cherokee basin. Earlier the same area was occupied by an important uplift, the Chautauqua arch, and still earlier, in early Paleozoic time, it had been a part of a great depositional basin. In late and middle Pennsylvanian time the Nemaha anticline stood across an area that had been previously the deepest part of the North Kansas basin.

Pre-St. Peter Structural Conditions. Seemingly all of Kansas was undergoing erosion for a long interval of time assigned to the earlier and middle parts of the Cambrian period. Likewise this part of the country probably was well above sea level for a long time before the deposition of the earliest Paleozoic rocks anywhere. No Paleozoic rocks older than those of Late Cambrian age are known in Kansas. Any sediments that may have accumulated in Early and Middle Cambrian time were removed before the Reagan standstone or Bonneterre dolomite was deposited. In Late Cambrian time much or all of Kansas became a part of a shallow depositional basin.

The Reagan sandstone seemingly did not accumulate over a continuous area but only in the lower places; it is possible places that later were to become important uplifts were positive elements of considerable height even then. As the basin became deeper the facies of the sediments changed and Bonneterre dolomite was laid down over probably all of Kansas, with possible exceptions being in the localities of the later uplifts. In general subsidence continued until Simpson (St. Peter) time, especially in eastern Kansas, but even there not without interruptions, as indicated by several unconformities.

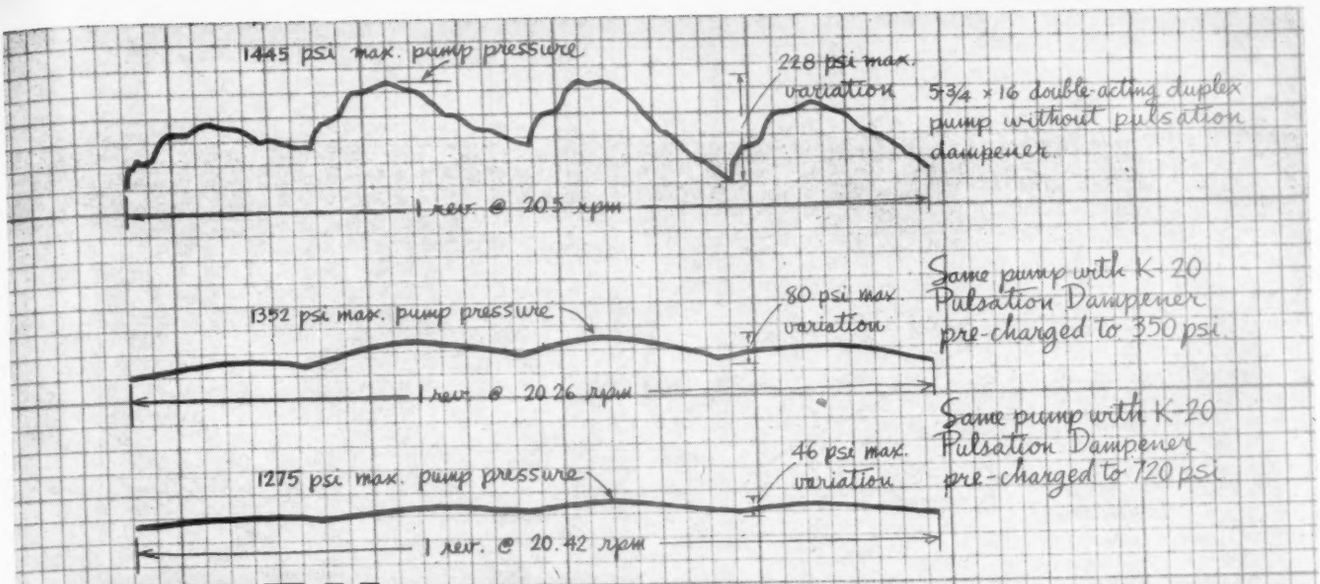
In part contemporaneous with the subsidence that produced in eastern Kansas what is known as the Ozark basin, relative uplift in northeastern Kansas and southeastern Nebraska produced the Southeast Nebraska arch, where the St. Peter sandstone oversteps older Ordovician and Cambrian beds almost or onto Pre-Cambrian rocks.

Post-Simpson Pre-Mississippian Structural Provinces. The unconformity lying next below the Chattanooga shale (lowermost Mississippian or uppermost Devonian) is an important and convenient datum horizon in subsurface studies in Kansas. Pre-Mississippian structures may be separated readily from those of later origin. A large area in northeastern Kansas contains Devonian and Silurian rocks ("Hunton") next below the pre-Chattanooga unconformity. In other places Ordovician formations lie immediately below the Chattanooga shale or Mississippian limestone. Many counties in southeastern Kansas lack Upper and Middle Ordovician rocks designated as Sylvan, Viola, and Simpson. In these areas the strata next below the pre-Mississippian unconformity belong to the Arbuckle group of Lower Ordovician and Upper Cambrian age. The same is true in several counties in central Kansas. This distribution of pre-Mississippian rocks defines structural patterns and areas of erosion that reflect the early geologic history of the state.

Chautauqua arch. At the beginning of Chattanooga time, a broad area of Arbuckle outcrop in the southeastern part of the state was flanked on the northwest by successively younger Ordovician formations having northeast trending outcrop belts. This is the northwestern extension of the Ozark uplift which, as shown by studies in Missouri, was undergoing differential elevation in Ordovician and Cambrian time and probably in Pre-Cambrian eras. This westward extension of the Ozark uplift, which is indicated by the distribution of Ordovician rocks in eastern Kansas, is known as the Chautauqua arch (Fig. 6).

Several known oil pools occur in the upper weathered part of the Arbuckle limestone in the Chautauqua arch area. The oil traps are in local "highs." Porosity largely is due to pre-burial weathering and perhaps partly to dolomitization. These Arbuckle pools are known as far eastward as in Montgomery and Labette Counties. Some Viola and Simpson in the western part of the Chautauqua arch are to be regarded as stratigraphic traps on the flanks of the uplift or on the flanks of the geologically younger Nemaha anticline. Beveled northwest-dipping pre-Chattanooga beds on the flank of the arch constitute the Ozark monocline.

North Kansas Basin. The North Kansas basin is a pre-Chattanooga structure that lies north of the Chautauqua arch and east of the Ellis arch (the ancestral Barton arch). Northward from the Chautauqua arch, the Chattanooga shale oversteps successively younger Ordovician rocks, including the Simpson (St. Peter) sandstone, the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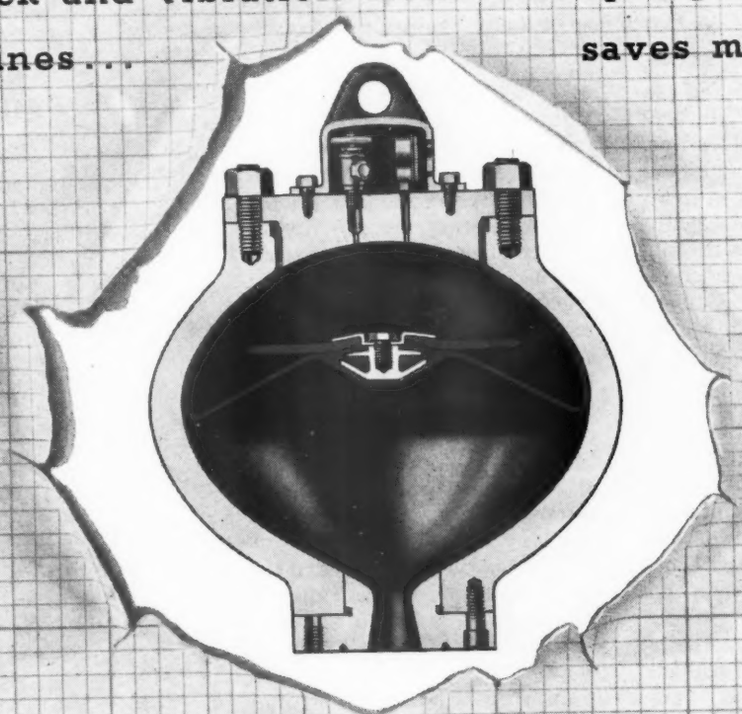

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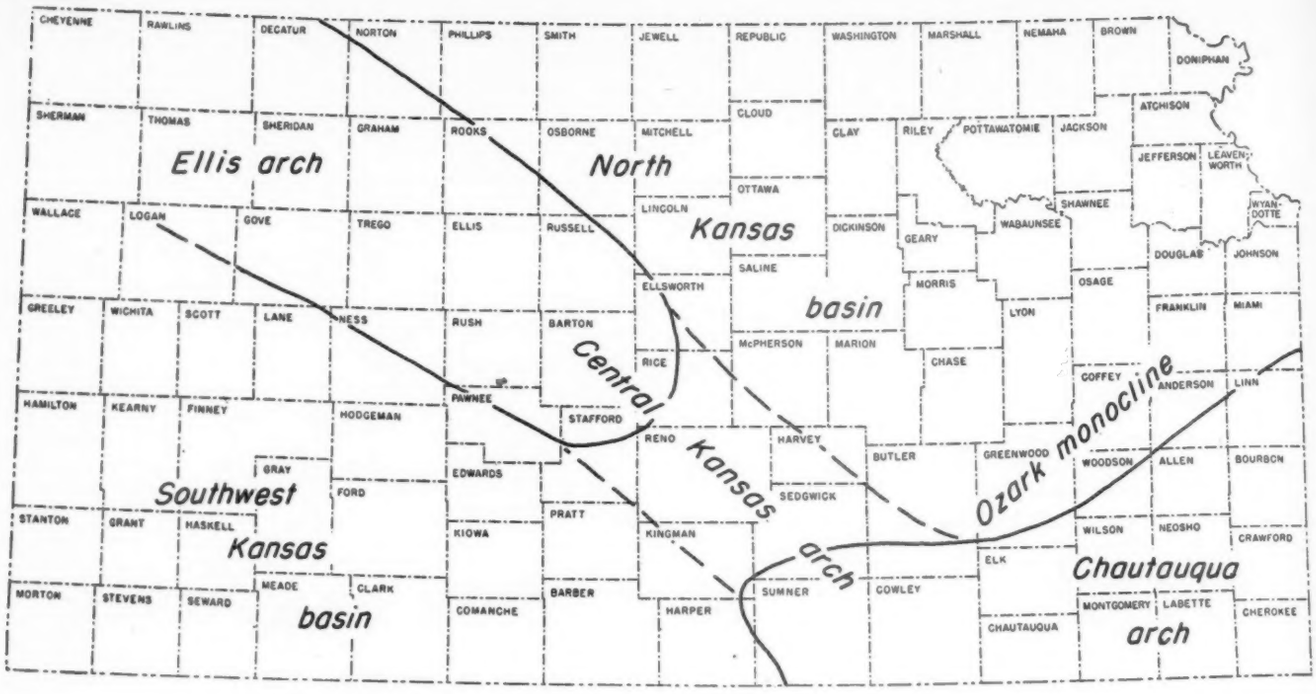


FIG. 6. Sketch map of Kansas showing pre-Mississippian structural provinces.

Viola dolomite, and Silurian and Devonian rocks known as the "Hunton" limestone. Hence in northeastern Kansas a much more complete Paleozoic section is present, but it is one of many unconformities. In Nemaha County, just east of the younger Nemaha anticline, more than 1000 ft of post-Simpson pre-Chattanooga sediments fill the deepest part of the North Kansas basin. In this area about 50 ft of St. Peter (Simpson) sandstone oversteps Cambrian beds and is believed, adjacent to the anticline, to overlap onto Pre-Cambrian rocks. Thus the older Southeast Nebraska arch is recorded.

Porosity in the "Hunton" limestone in northeastern Kansas largely is due to weathering in pre-Chattanooga time. The "Hunton" oil pools in Brown and Nemaha counties, like those in the Viola and Arbuckle in various parts of eastern Kansas, may be regarded in part as being in stratigraphic traps, inasmuch as the pre-Chattanooga and pre-Maquoketa surfaces are beveled and undoubtedly weathering was differential in accordance with the lithology of various beds.

The North Kansas basin was the site of extensive sedimentation during Mississippian time also. There are numerous disconformities in the Mississippian section, as well as in the lower rocks. Stratigraphic traps may occur at several horizons. Certainly there are many zones of porosity.

Ellis arch. Southwest of the North Kansas basin, in the region now defined as the Barton arch or the Central Kansas uplift, Mississippian rocks are absent and Pennsylvanian beds lie on Ordovician, Cambrian, or locally Pre-Cambrian rocks. The strikes of anticlinal folds in these pre-Pennsylvanian rocks trend northwestward and differ from the axis of the later uplift. These folds seemingly are pre-Mississippian and are aligned with folds in the Chautauqua arch. In fact this early structure together with the Chautauqua arch is regarded as the real backbone of Kansas structure and has been called the Central Kansas arch. Highs, such as the Burns dome, on the Nemaha anticline are believed to be due to post-Mississippian movements along trends in accordance with the ancient grain marked by the Central Kansas structure.

Distribution of oil pools in the Barton arch region, Kansas' most prolific area, largely is due to the structures more directly related to the ancient Ellis arch than to the later structure, and in studying the accumulation of oil and gas in that part of the state it is important to differentiate bteween the Ellis arch and the later Barton arch.

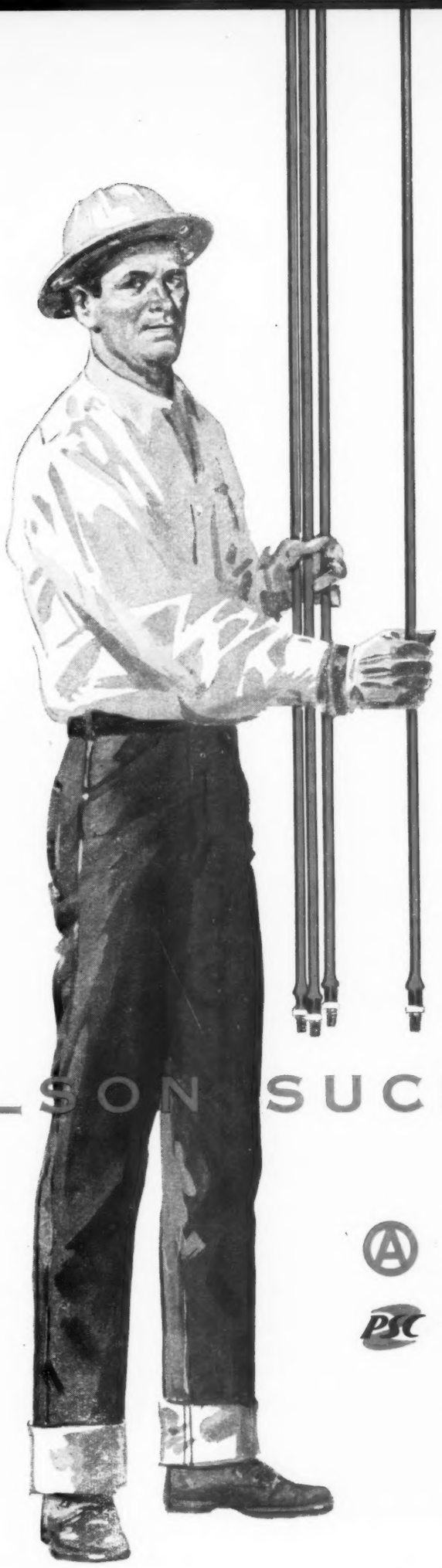
Southwest Kansas basin. Southwest of the Ellis arch and west of the Chautauqua arch is a basinal area of pre-Mississippian date which has been called the Southwest Kansas basin. This is to be regarded as a basin principally because of its relations to the great Central Kansas up-lift—the combined Ellis and Chautauqua arches. Erosion or nondeposition in pre-Mississippian time, however, was more prevalent there than in the Northeast Kansas basin. This southwest Kansas area, too, was the site of extensive Mississippian sedimentation. The deepest well that has been drilled in Kansas is in this area.

It is the Stanolind Oil and Gas Company No. 1 Pearl Feather, sec. 15, T. 35 S., R. 33 W., Seward County. The following datum points were recorded: top of Mississippian rocks, 6200 ft; top of Simpson, 7965 ft; top of Arbuckle, 8013 ft. Total depth of the well is 8043 ft. Elevation of the well was reported as 2823 ft. It is believed that in the area the thickness of Arbuckle rocks ranges from about 250 to 650 ft.

Fig. 6 is a map of Kansas showing the positions of the Central Kansas arch and of the two ancient basinal areas.

Post-Mississippian Structural Provinces. A map showing the post-Mississippian structural provinces as defined in Kansas is shown in Fig. 7. These structural features inherit some of their attributes from anticedent tectonic characters, but mainly they seem to have originated in structural movements that occurred in early Pennsylvanian time, probably post-Morrowan and pre-Desmoinesian. It should be noted that these too are mainly subsurface structures and are reflected only slightly in outcropping rocks. It is convenient to refer Kansas oil and gas fields to these post-Mississippian structural areas and to regard them as petroliferous provinces. Mentioned in previous paragraphs, however, many of the deeper petroleum reservoirs owe their origin at least in part to pre-Mississippian tectonic movements.

Nemaha anticline. An anticline, whose buried crystalline core often is called the "granite ridge" or the Ne-



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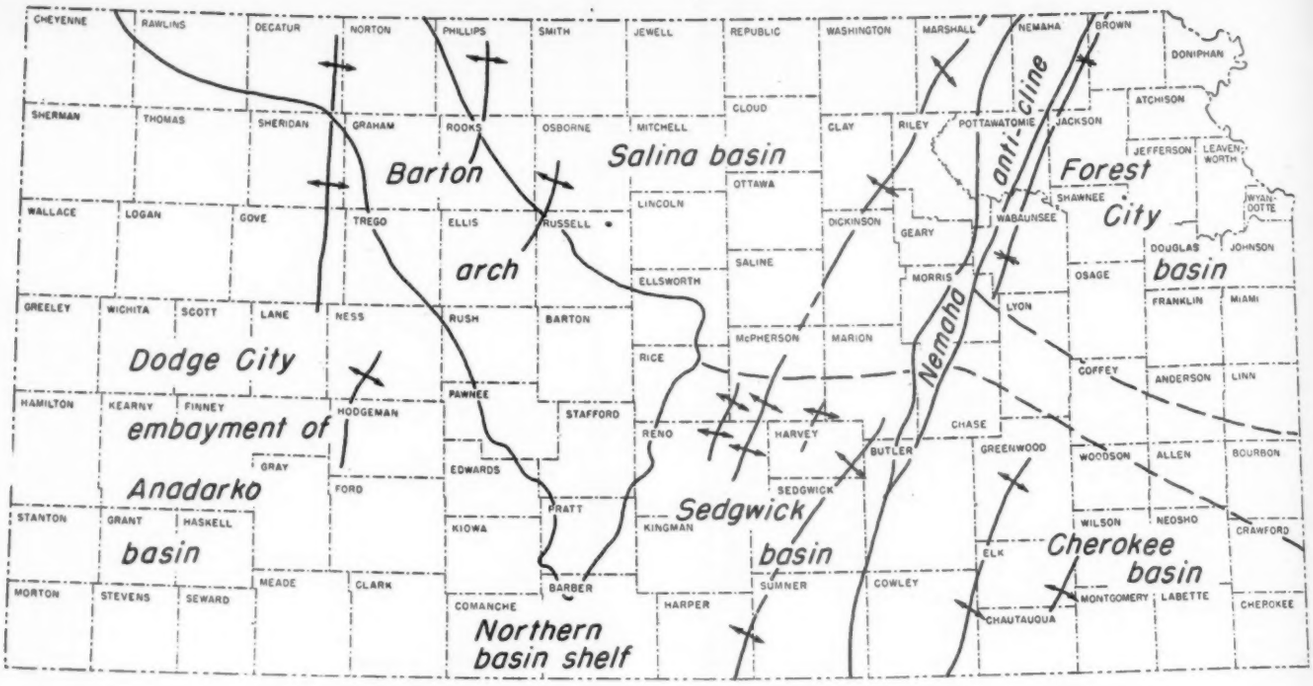


FIG. 7. Sketch map of Kansas showing main post-Mississippian structural provinces.

maha Mountains and which trends south-southwestward across Kansas from Nemaha County to Sumner County, ranks with the Barton arch, farther west, as being by far one of the two most important uplifted areas in Kansas. Mississippian and older rocks are tilted and eroded on the flanks of the anticline, which in most places along its length is steeper on the east than on the west. Undoubtedly the east flank is faulted (Fig. 7)

Pennsylvanian sediments on the anticline overlap and overstep rocks ranging in age from Mississippian to Pre-Cambrian. Along the crest of the uplift, Pennsylvanian sediments lie on Pre-Cambrian rocks in a belt extending northward from a point in T. 11 S., R. 10 E., and in isolated areas farther south. The part of the granite ridge farthest north in Kansas was not covered with Pennsylvanian sediments until about the end of middle Pennsylvanian time. Older Pennsylvanian beds overlap Pre-Cambrian and older Paleozoic rocks along the southern part of the uplift's axis. In general Pre-Cambrian rocks lie about 2000 ft lower a short distance east of the anticline than on its axis. Although the Nemaha structure may be said to extend as far south as Oklahoma City or even to extend into the Arbuckle-Wichita system, it becomes somewhat discontinuous south of Butler County, Kansas.

Geologic history of the Nemaha anticline has been made known largely through the studies of Wallace Lee.

In Nemaha County, on the state's northern boundary, less than 600 ft of Pennsylvanian sediments lie on Pre-Cambrian rocks on the axis of the anticline, but southward the sedimentary cover increases in thickness. Along the axis in Butler County (except on the highest part of the granite core) a thin section of Arbuckle rocks lies between the crystalline rocks and about 2250 ft of Pennsylvanian and Permian beds.

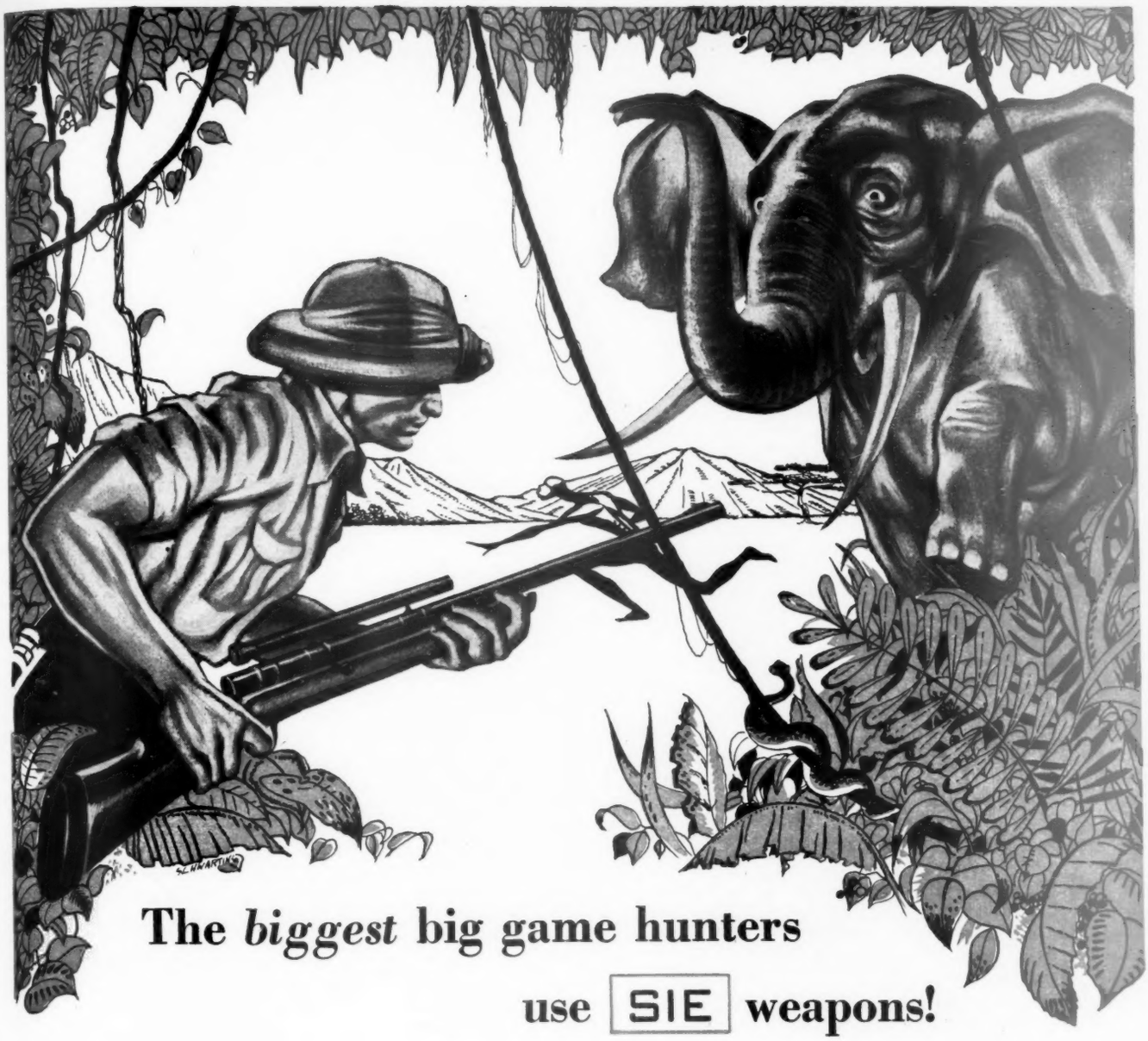
The famous El Dorado and Augusta oil fields lie in and on the flanks of the Nemaha anticline. At El Dorado and Augusta the chief producing zone is along the beveled pre-Pennsylvanian surface cut in Ordovician rocks. Higher rocks, the Pennsylvanian section, also are oil reservoirs. Several other fields, mostly on the flanks of the uplift in its southern part, yield great quantities of oil from Ordovician, Mississippian, and Pennsylvanian pools.

Barton arch. Although the term Central Kansas uplift is commonly applied to this important structure, Barton arch is the preferred name. The Barton arch trends north-northwestward from south-central Kanas (Fig. 7). Evidence of its post-Mississippian origin, like that of the Nemaha anticline, is found in the tilted and truncated margins of Mississippian and older strata on the uplift's flanks and in the absence of Mississippian rocks in its central part. Older Pennsylvanian rocks also are missing from the higher parts but overlap of younger beds ultimately led to complete coverage.

In places oil and gas are obtained from porous weathered rocks ranging to Pre-Cambrian in age, just below the overlapping Pennsylvanian sediments. Pennsylvanian strata overlying the uplift, especially the highest parts, including "buried hills," likewise yield oil. In places as in the area of the Silica field, Barton and Rice counties, karst topography developed on Arbuckle limestone surfaces before burial under Pennsylvanian beds. Porous Arbuckle limestone reservoirs are interrupted by ancient sink holes filled with nonporous basal Pennsylvanian accumulations.

Forest City basin, Bourbon arch, and Cherokee basin. Thinning of Cherokee sediments in a narrow area extending northwestward from Bourbon County to Lyon County (Fig. 7) indicates that briefly eastern Kansas was separated into two depositional basins, the Forest City in the north and the Cherokee in the south. The low separating structure expressed in pre-Pennsylvanian rocks is known as the Bourbon arch. The thickness of Mississippian limestone increases from 300 ft or less on the arch to more than 450 ft in Miami County on the north and to more than 350 ft in northern Allen and Bourbon counties on the south.

The Forest City basin extends into northwestern Missouri, southeastern Nebraska, and southwestern Iowa. Pennsylvanian sedimentation seemingly began earlier in the Forest City basin than in the Cherokee basin. The Cherokee basin is the Kansas part of the sedimentation area that extended far into eastern Oklahoma, where Pennsylvanian rocks older than any known in the Forest City basin occur. The Nemaha anticline marks the west boundary of the two basins. Although the separating Bourbon arch may have been an area of meeting of sediments from southerly and northerly direc-



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tions at several times in middle and late Pennsylvanian time, in general the two basins may be regarded as one continuous structural province of great lateral extent, containing in northeastern Oklahoma and probably in Iowa Pennsylvanian sediments older than any known in eastern Kansas. The synclinal area in the western part of the combined structure is of special interest.

The Davis Ranch oil pool, Wabaunsee County, is in an anticline that is believed to be a higher part of a longer fold that is parallel to the Nemaha structure and contains also the Ordovician oil pools that have been found farther north in the county. Pools in pre-Mississippian rocks, in Lyon County to the south, and in Nemaha County far to the north, are on the same trend and in the light of present knowledge, are believed to be in a series of **en echelon** folds parallel to the Nemaha structure. This synclinal area is known as the Brownville syncline.

Farther south, as in Cowley County, and east of the anticline, there are several **en echelon** folds detectable in outcropping rocks and more pronounced in buried formations (Fig. 7). These exemplify some trends that may be designated Slick-Carson, Graham, Rainbow Bend, and Otto-Dexter. The latter seemingly is a part of the long Beaumont anticline which extends far to the northeast across Greenwood County. Many miles farther east are the Longton (Elk County) and the Fredonia (Wilson County) anticlines. These are cited as examples of anticlinal folds in southern Kansas and in general parallel the Nemaha structure. All contain prolific oil pools.

In the Forest City basin a maximum of slightly less than 4000 ft of sedimentary beds overlie the Pre-Cambrian crystalline rocks. This thickness, however, is encountered only in the deepest part, in the Brownville syncline, in a place that is also in the deepest part of the more ancient North Kansas basin. More nearly average thickness of Paleozoic rocks in the Forest City basin area is 2500 ft.

On the Bourbon arch, near the Kansas-Missouri line, Pre-Cambrian rocks are reached at a depth of about 1500 ft. In the extreme southeast part of Kansas, about 1500 ft of Mississippian, Ordovician, and Cambrian rocks lie above the crystalline floor, but in the deepest part of the Cherokee basin, in Cowley County, 5500 or more feet of sediments (Permian, Pennsylvanian, Mississippian, Ordovician, and Cambrian) cover the basement rocks.

By far the greatest amount of oil that is found in eastern Kansas in the two basins has come from sandstones, principally in the lower part of the Pennsylvanian section. Much of the production has been from "shoestring sands" that in part are off-shore bars and perhaps in part channel fillings. The oil pools are in sedimentary traps; accumulation was localized by changes in porosity. In some areas more sheet-like sand bodies are productive in local structural "highs."

Salina basin. Lying between the Nemaha anticline on the east and the Barton arch on the west is the Salina basin. This structure, superposed like the Forest City basin on the more ancient North Kansas basin, contains a thick section of older Paleozoics. About 350 ft of Mississippian limestone occurs in the deepest part in Saline County. Mississippian limestones were peneplained before burial under Pennsylvanian sediments. Important oil fields in the basin are in Saline County, where the current annual production is more than a million barrels of oil. Nearly all the known pools are in the Viola limestone at depths ranging from about 2675 to 3430 ft. A few fields produce oil from the Mississippian at a depth of about 2650 ft.

Sedgwick basin. A basinal area lying southeast of the Barton arch is known as the Sedgwick basin. It is set off from the other post-Mississipian structural provinces, partly because of its geographic location in respect to basinal areas to the north and west, and partly because of the general nature of the geologic structure and production in fields of the region. This area has been a very important producer of both oil and gas, mainly in anticlinal folds located on trends that generally are parallel to those of the Nemaha anticline. The Bluff City (Harper and Sumner counties), the Valley Center (Sedgwick County), and the Elbing (Marion County) anticlines comprise such a trend. Farther west, the Voshell anticline is in alignment with the Barneston arch, which is in the eastern part of the Salina basin.

Dodge City embayment. The Dodge City embayment, occupying most of western Kansas, is in reality the northern extension of the great Anadarko basin, most of which is in Oklahoma. This structural province in Kansas is not sharply separated from the Sedgwick basin, but thinning of Mississippian limestone in western Barber County offers a reason for extending the Barton arch southward as shown in Fig. 7. It is probable that the Las Animas arch of southeastern Oklahoma in part limits the northward extension of the Dodge City structure. This structural province sometimes is called Hugoton embayment. Seemingly the deepest part is in the vicinity of Hugoton rather than Dodge City, but the latter name is preferable because of priority and because Hugoton trough is used locally for the deepest part in Kansas.

Oil production, especially from Pennsylvanian rocks, is becoming important in the Dodge City embayment, but as pointed out in another part of this article it is the great Hugoton gas field that to date gives tremendous importance to this petroliferous province.

Prairie Plains monocline. Kansas has been affected by still younger movements that have produced "structural provinces" superposed on those described above. The name Prairie Plains monocline has come into general usage over a long period of years to designate eastern Kansas and parts of neighboring states in respect to structural attitude of surface rocks. Outcropping Permian and Pennsylvanian rocks generally dip gently outward from the Ozark dome and westward into a Mesozoic basin. Hence the Prairie Plains structure is more or less indefinitely limited. Chiefly it is post-Permian in age. Overstep of Cretaceous sediments on beveled Permian beds in eastern Kansas and on beveled Pennsylvanian strata in Nebraska and Iowa indicates pre-Cretaceous age of the tilting and beveling. It is believed that the crests of east-facing escarpments in eastern Kansas mark the position of an early Mesozoic peneplain. Gravel was deposited on much of the peneplained surface in late Tertiary time.

It is to be noted that the westward or north-of-westward dip of upper Paleozoic rocks in eastern Kansas is interrupted by the gentle folds over the Nemaha anticline and other structures where the original movements date far in advance of the Prairie Plains structure.

Without deep post Pre-Cambrian sedimentary basins as are found in neighboring states Kansas has, in her relatively thin veneer of Paleozoic rocks, a very large number of prolific petroleum reservoirs. There are several scores of producing formations, extending from the Permian, with gas even higher in the Cretaceous, down into the Pre-Cambrian basement rocks. Production of oil and gas continues to increase each year, and with discoveries increasing at a rather amazing rate, Kansas' proved reserves are quite satisfactory. Probable reserves, too, are large. With more than 85 years of commercial production behind it, it is believed that Kansas will for a long time remain in the half dozen or fewer big oil states. ★ ★ ★

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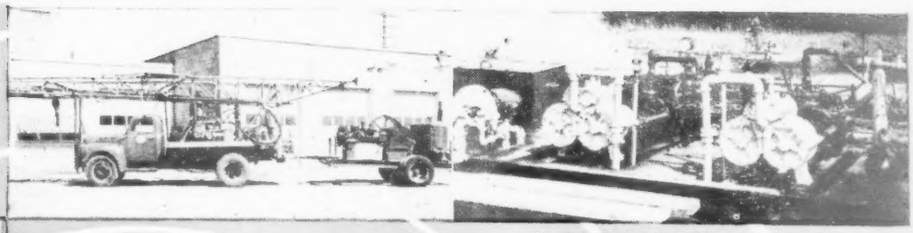

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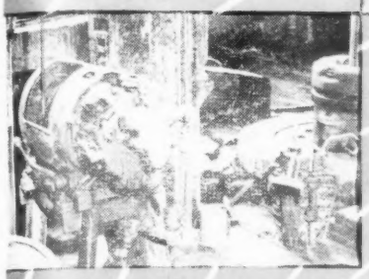

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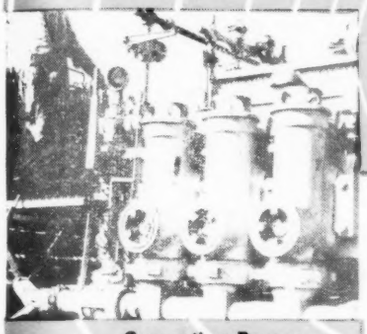

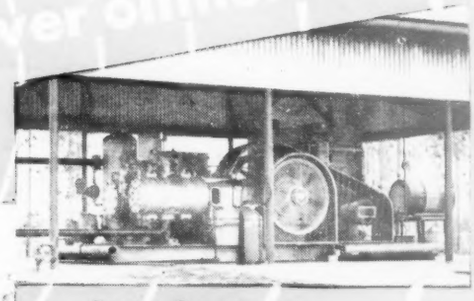

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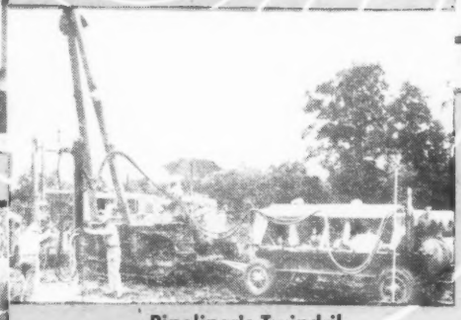

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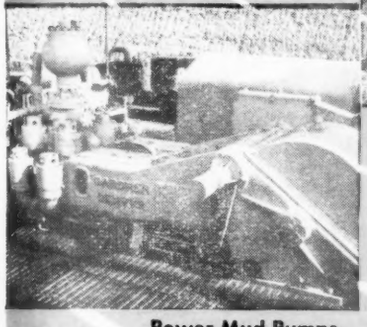

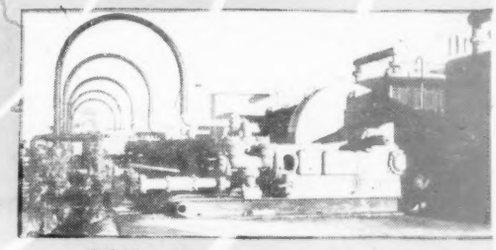

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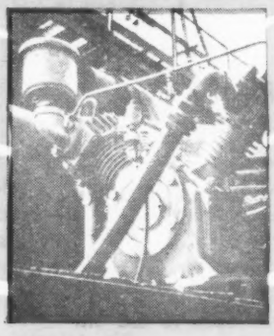

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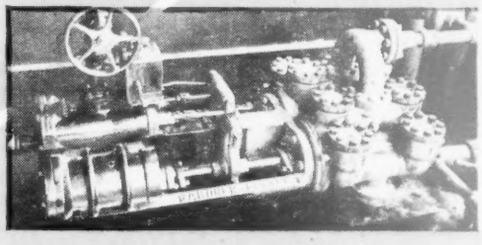

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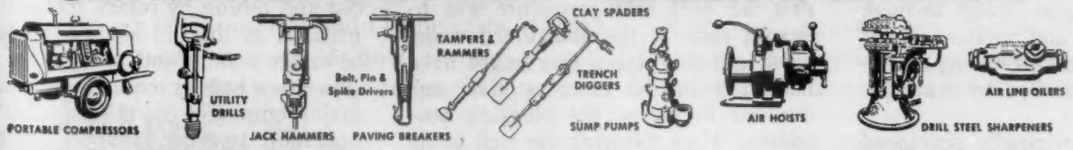

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FIG. 1. Trailermast rig in roading position. Maximum axle load of 18,000 lb, width 8 ft, height 13 ft 5 in., and length of 60 ft, make for easy portability.

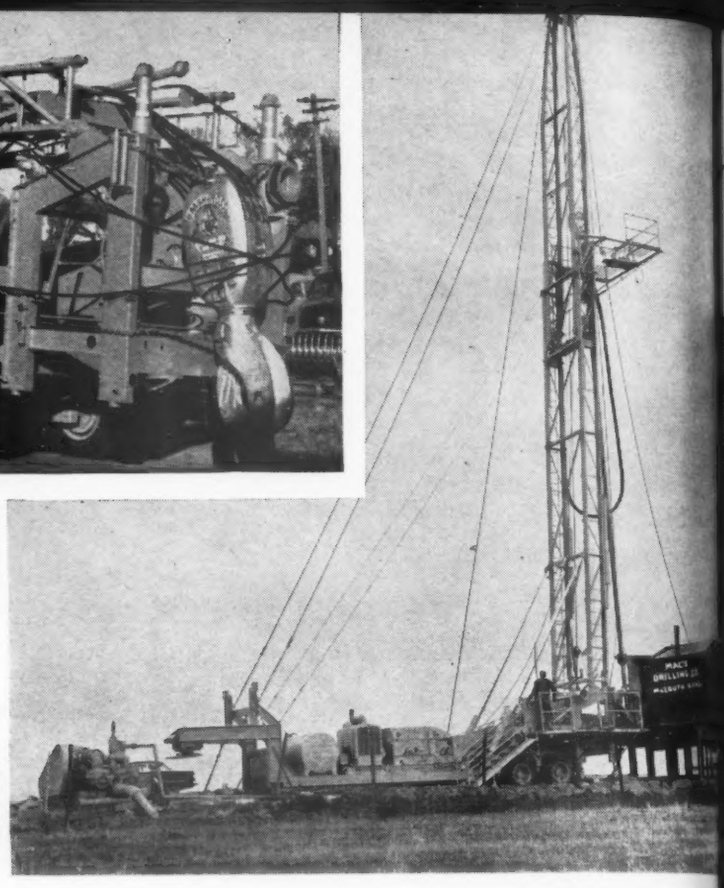


FIG. 2. Rig on location and operating. Hydraulically erected and telescoped to full 84-ft height by line to drum. Mast was entirely adequate for designed drilling and workover operations.

P 422

New Rig Reopens Old Wells

Specially assembled to work-over abandoned wells in Kansas gas storage project, machine also proves valuable in drilling new holes

CHARLES SPITZFADEN

THE project of developing an underground gas storage reservoir in Northeastern Kansas provided many problems for the equipment manufacturer as well as for the developers of the project—Cities Service Gas Company.

In brief, the project involved the general reworking of an old abandoned gas field with the ultimate aim of arriving at a completely sealed underground gas storage zone with a selected number of properly drilled and cased input and discharge wells through which the volume and pressure of gas stored in the original producing formation could be controlled by the operator.

This area was originally developed years ago, at which time only cable tool methods of drilling were in common use. Gas was produced from the area and the wells progressively exhausted and plugged under conditions and through the use of practices then in general acceptance. Unfortunately, plugging methods in that period were rather casual; therefore, one of the biggest problems in developing this later project was to determine that these old abandoned wells were thoroughly sealed so that subsequent application of gas pressure to the old producing zone would not permit gas to escape.

Reopen Abandoned Wells

It was determined by the operator that the only safe procedure was to reopen each of the abandoned wells, clean out everything that might have been left in the hole, or that was dumped in during the plugging procedure. After restoring the well to its original drilled depth, each was to be thoroughly re-plugged through the use of present cementing and plugging procedures so as to insure a completely sealed reservoir.

EXCLUSIVE

In addition, it was necessary for the operator to drill and case certain new wells to the depth of the old gas producing zone so as to provide reliable input and discharge access to the reservoir at properly spaced intervals.

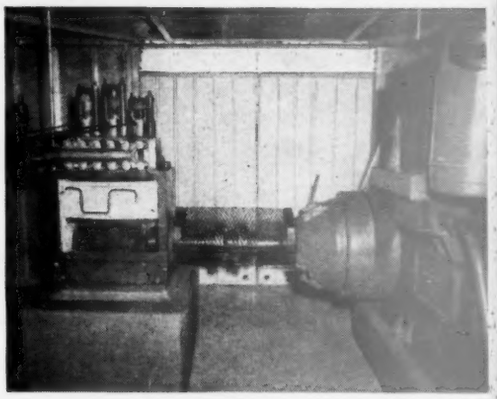
Developing Project

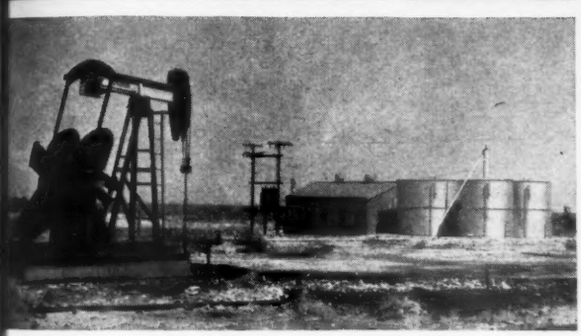
The work of developing this project, from the standpoint of the drilling contractors hired by the operator, became a twofold operation of cleaning out and fishing by rotary methods for material in the old abandoned holes, as well as drilling and casing the occassional new hole as required — with the major emphasis on the first type of operation. In order to supply the desirable type equipment to fit this problem, it was necessary to satisfy seemingly conflicting requirements.

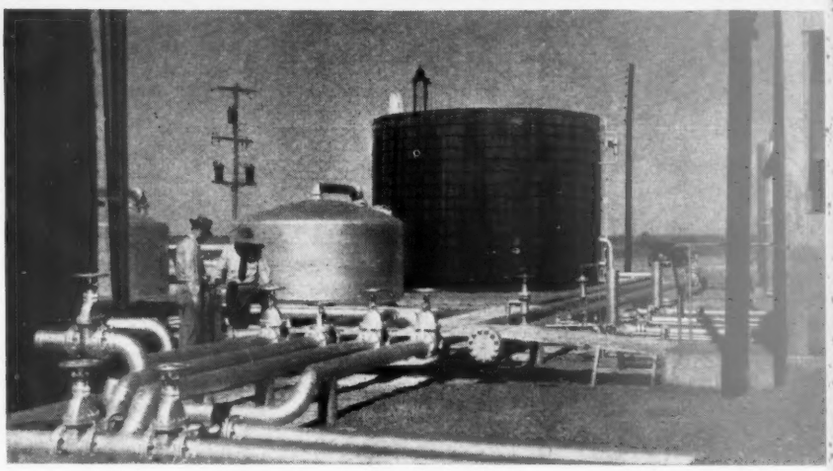
In the first place, the depth was shallow (1400 to 1700 ft) which normally would require only very light draw works and mast equipment. In

XUM

Need Help for Your Waterflooding Problems?







When you decide to install a pressure system for waterflooding, Bethlehem can readily design and furnish a turnkey layout that embodies every needed item of equipment. It will include buildings, treating and injection facilities, pipe lines, valves, surface pumps, compressors, storage tanks, prime movers, generators, controls, substations, line poles, wiring, pumping units, sucker rods, bottom-hole pumps, etc.

{Incidentally, when it's time to consider the pumping units, remember that Bethlehem offers the largest selection of long-stroke pumpers in the business.}

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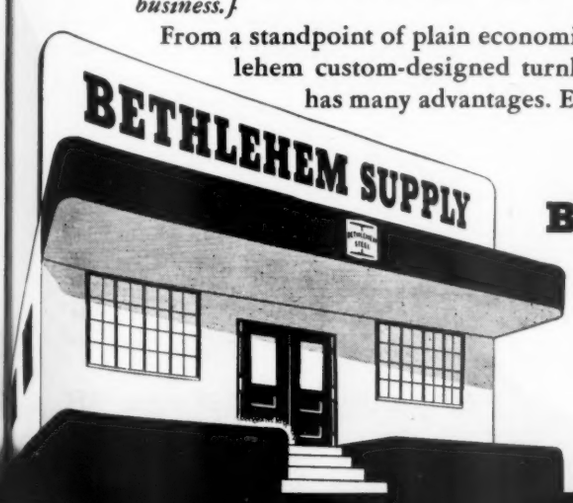

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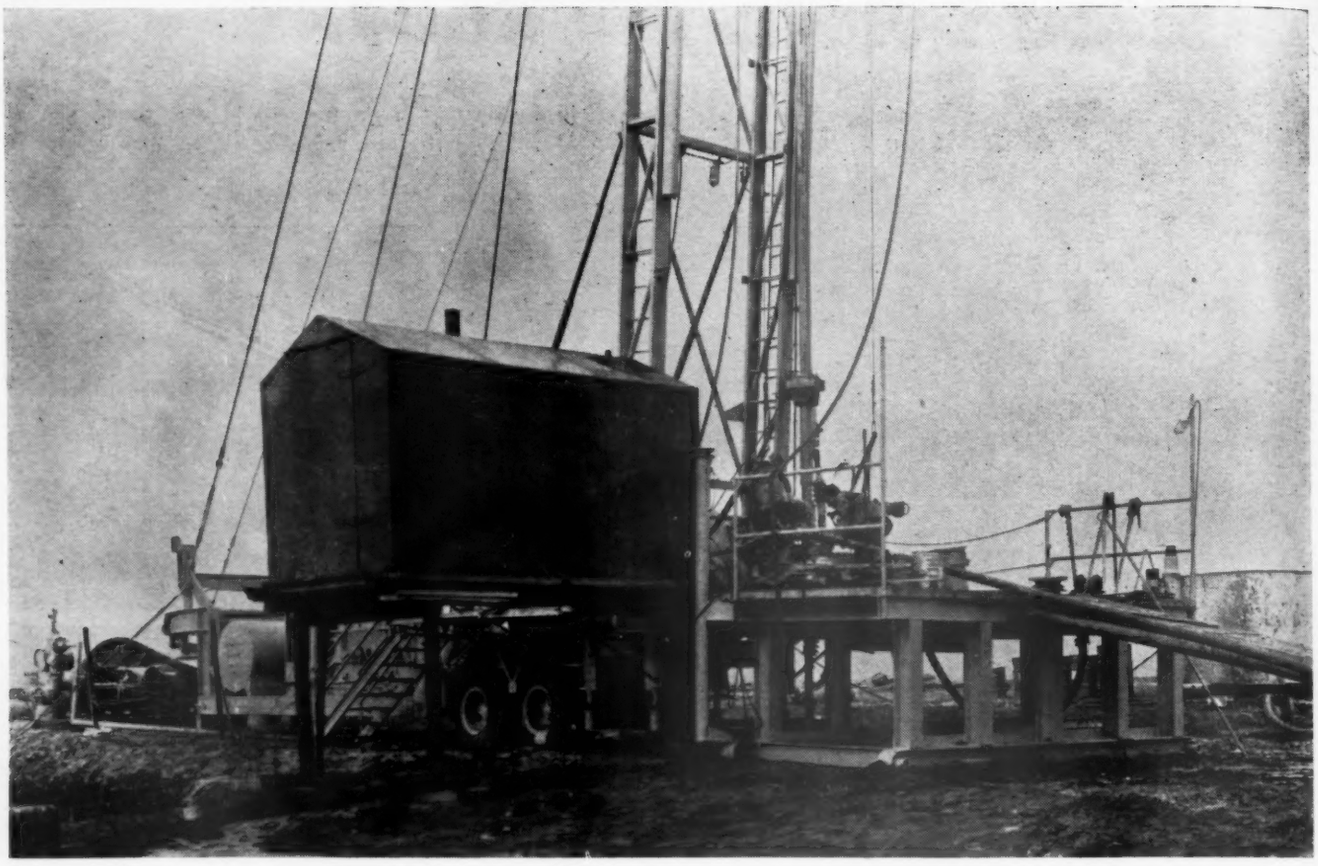

FIG. 3. Rig was provided with a 16 by 16-ft working platform providing ample floor space and adequate under-floor clearance.

addition, many of the jobs were of only one or two day duration which, of course, demanded portable equipment that could be moved in, rigged up, and put to work with a minimum of time and expense. On the other hand, because of the predominance of fishing work anticipated (which at times would require round trips with the drill pipe string), it was preferred that the rig be equipped with a full-size mast which would handle and stand doubles — or sixty-foot lengths — of drill pipe.

It was also desired to have the rig provide an elevated derrick floor so as to permit under-the-floor connections for cementing operations without the necessity of elevating the entire rig on a typical structure. It was essential also that the rig be so arranged as to permit operation with a three-man crew.

A rig complying with all these requirements was built and assembled for one of the contractors by Cardwell Manufacturing Company, Inc., of Wichita, Kansas, and proved to be one of the most efficient and suitable for the work encountered. Its principal elements were the combination of a Cardwell Model 152 Trailermast with a Cardwell Model AH single drum draw works. The complete package consisted of the draw works and its engine, 500-gal diesel fuel tank, 5 kw light plant, 84-ft telescoping structural mast with provision for carrying the block and hook strung up in operating position, all assembled into one roadable semitrailer unit, as shown in Fig. 1.

In addition, a structural steel, wood-decked, working platform and rotary table support beams for bolting to the rear end of the trailer after spotting on location, were furnished. This provided a 16 by 16 ft unobstructed rotary floor and pipe racking deck 5 ft above ground and basic rig level.

In roading position, as shown in Fig. 1, the rig and truck weighed only a total of 68,750 lb, with a maximum axle load of 18,000 lb on the trailer. Dimensionally, the unit was within 8-ft road width; 13-ft 5-in. high including the folded racking platform and tong line counter-weight boxes; and 60 ft long including the hauling truck. It, therefore, presented no hauling problem and the weight distribution made it an easy unit to move down the road.

Model 152 Trailermast conformed also to the requirement that the rig be easy and quick to assemble and tear down. With the mast being carried in a fixed position, there is no necessity for additional truck assistance on location to spot the mast into position for raising. After leveling the trailer with self-contained screw jacks, the mast is raised into operating position through the use of the built-in hydraulic system and two five-stage hydraulic rams. Two additional single-stage rams are automatically brought into contact with the front legs of the mast as it reaches the vertical and thereafter, lower into final operating position, so that at all times the mast is under full control of the operator.

The major load-carrying guy lines are permanently affixed to the rear legs of the mast and the supports at the trailer goose-neck, so that, once adjusted, they too automatically come into proper tension as the mast reaches operating position. The upper section of the mast is telescoped to full 84 ft height through the use of either a telescoping cable, powered by the draw

The Author

Charles Spitzfaden is sales representative for Cardwell Manufacturing Company. A graduate mechanical engineer from Washington University, he joined Continental Supply as machinery engineer in 1937. From 1942 until 1946 he served in the U. S. Navy, and rejoined Continental as assistant district manager in the Wichita, Kansas, area. In 1947 he became sales representative for Kansas, Nebraska, and Eastern Colorado for Cardwell.

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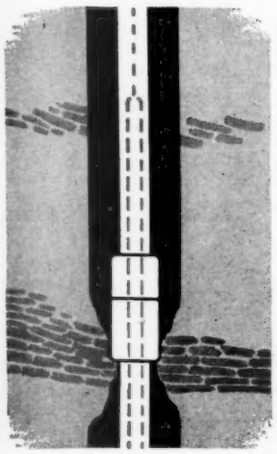
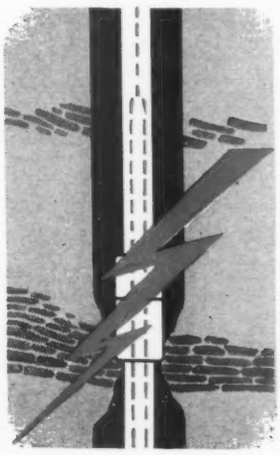
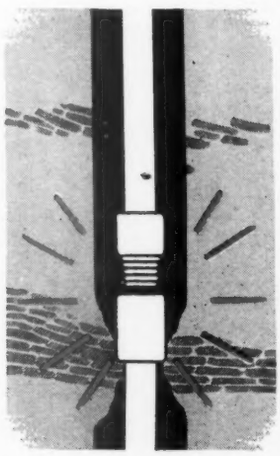


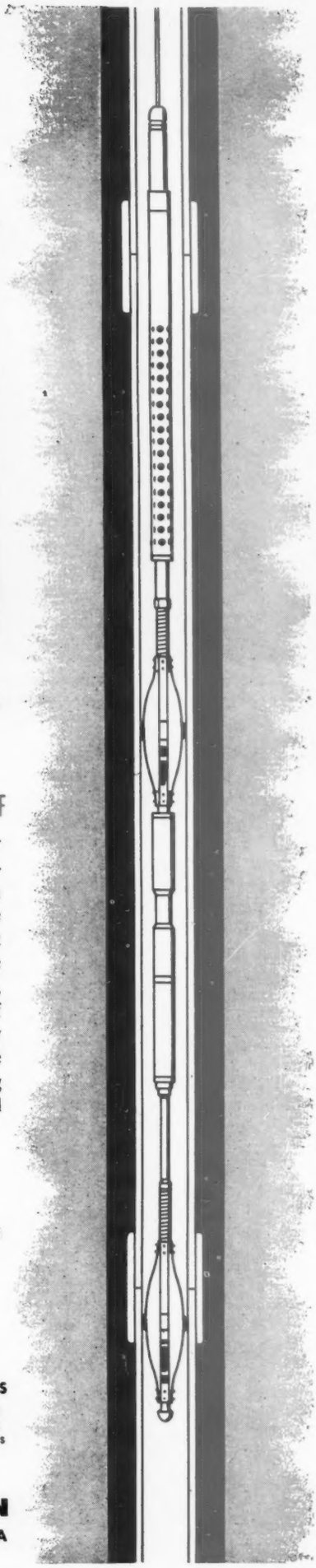
Free Point Indicator locates lowest depth where stretch and torque can be applied on the drill string.



The "String Shot" is lowered to the same depth on the same cable and detonated to loosen tool joint.



Back off recovers stuck drill pipe, drill collars, tubing or casing to permit further fishing operations.



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This tool accurately determines the lowest depth where *both stretch and torque* can be applied to the drill string. It locates the exact point where stuck drill pipe, drill collars, tubing or casing can be freed. Movements as small as *one-thousandth of an inch* are recorded electronically on a surface indicating panel. Since reverse torque is used to back off, pipe to be recovered must be free in torque as well as stretch. *The Dia-Log Free Point Indicator gives you this correct depth in a matter of minutes!*

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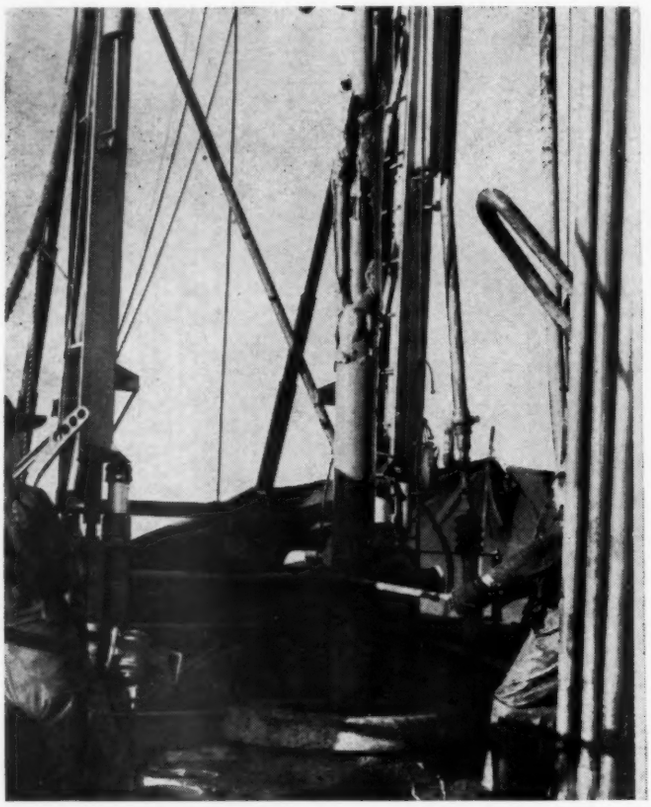

FIG. 4. Removal of junk from improperly abandoned wells was major problem. Here, section of 6⅝-in. casing is pulled.

FIG. 5. Miscellaneous junk from one well laid out on pipe rack. Early operators used plugged wells to dispose of scrap.

works drum, or a separate hydraulically powered small truck type winch. This telescoping operation is also under full control, for the upper section is provided with slips that automatically would be set should there be any mechanical failure in the telescoping line. With a minimum of additional ground guying, mainly for wind loading, the rig is just about ready to go to work by the time the mast is telescoped, as the block and hook remain strung up at all times. Fig. 2 shows rig erected at work on typical location in this area.

The "Trailermast" arrangement permitted compliance also with the requirement that the driller be positioned close enough to the floor so as to assist in handling tongs when operating with a three man crew. A remote control panel, through which all functions of the rig are handled, was positioned just off the rotary floor and behind the auxiliary cathead shaft. In this way, the driller was close to the floor area and yet was in the safest possible position with respect to the spinning cathead. Fig. 2 illustrates this feature and it can be seen that there would be little danger of entangling the driller in the spinning line. The driller's platform is carried forward toward the well and exactly meets with the top of the rotary floor and working platform so that there are no steps or ramps to be tripped over, or slipped on, in the working area. Fig. 3 illustrates the working platform which is provided with a tong back-up post, safety handrails, and a built-in rat hole digger.

The Model AH single drum draw works installed in this rig has a rated capacity of 2500-ft, using 3-½ in. OD drill pipe, and combines the latest developments in Cardwell air operated friction clutches throughout. In this instance, it was powered with a Model 4031-C General Motors four-cylinder diesel engine rated at 100 hp, and a five speed and reverse Spicer gear transmission to provide the range of speeds for efficient operation. This combination of engine power and transmission proved to be very well suited both as to size and flexibility for the work encountered, and particularly right for the wide range of speeds and pulls required by the many types of fishing operations which were experienced.

The remaining major items completing the rig were a 6-in. by 12-in. Oilwell slush pump unit powered by a six-cylinder General Motors diesel engine, an 18-in. oilbath rotary table, and appropriately sized swivel, block, and hook, etc., to work with the 150,000-lb working hook load capacity mast.

In operation the rig lived up to the expectations of the designer and operator by efficiently performing the many tasks assigned. It satisfactorily handled every type of fishing operation encountered and cleaned up several bad jobs that were beyond the capacity of other equipment available in the area. Fig. 4 indicates a typical "fish" which was recovered from one of the old "plugged" holes and is actually a piece of old 6⅝-in casing, which was shot off and left in the hole at the time it was abandoned and plugged. It can readily be seen that a good share of the success of such an operation depended on the contractor's ability to properly identify the type and shape of each "fish" encountered and thereafter select and properly handle the correct tool to make the catch. Almost as important was the rig's ability to comply with each demand for minute movements of the drill string and very light pulls, up to getting the pipe moving fast and out of the hole — or at times delivering sledge hammerlike wallops and extreme pulls to the stuck pipe. An idea of the variety of shapes and sizes to be found in one hole can be obtained from Fig. 5 which displays some of the "junk" as laid out along the pipe rack.

The rig also proved itself to be a "hole maker" by drilling and casing new holes in record time and with a minimum of cost.

This project — now completed — provided interesting problems for all concerned and proved once again that successful operations in the oil country are the result of the combined "know-how" of the operating company, the contractor and designer and manufacturer of equipment to perform the tasks assigned. * * *

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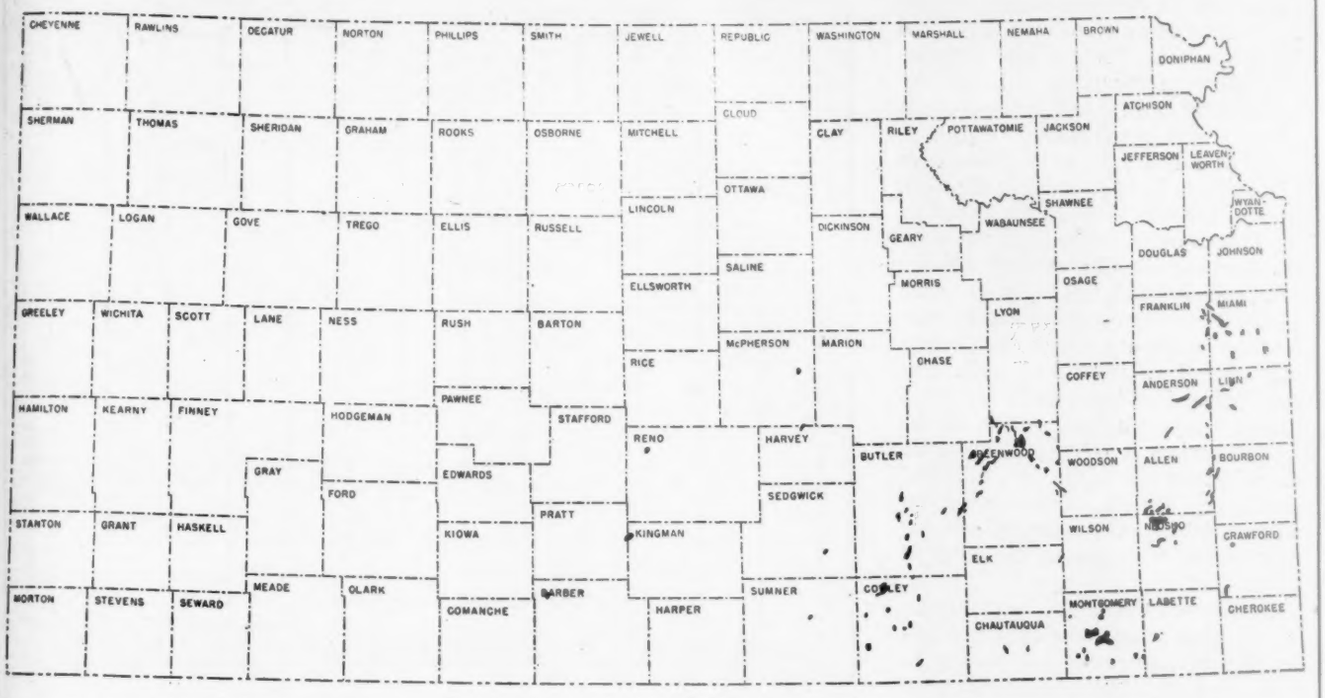

FIG. 1. Index map of Kansas, showing areas in which oil is produced by secondary recovery methods.

Secondary Recovery of Oil in Kansas

At beginning of 1953, there were 170 projects in the state of which 143 reported 5902 wells producing oil by secondary recovery mostly waterflooding

EDWIN D. GOEBEL

REPRESSURING of oil-bearing strata by injection of water, air, or gas or a combination of these agents has become a principal method of oil production in Kansas (Fig. 1). It was in the Pennsylvanian and western New York fields, more than 50 years ago, that the benefits of waterflooding oil-bearing strata were discovered accidentally. Oil operators in that part of the country observed increased oil production rates when water leaked past corroded casings of oil wells into the producing horizon.

Water-flooding in Kansas, although practiced in sundry manners in Chautauqua and Montgomery counties for more than 35 years, received its official sanction and status through passage of a law by the Kansas Legislature in 1935. Early methods practiced in Chautauqua and Montgomery counties consisted mostly of allowing upper strata water to gravitate into lower oil-producing beds. This method is known to have increased oil production appreciably from many fields; however, extent to which method affected production in the two counties is not known.

First legal project commenced under the new Kansas statute was started on May 15, 1935, in the Seeley pool of Greenwood County by York State Oil Company.[2] Water was injected on that date into the Bartlesville sand at a depth of 1940 ft. Two other projects were begun later in 1935. The Wiser Oil Company Paulus flood in Chautauqua County was begun in September when water was injected into the Peru at a depth of 1100 ft. The Texas Company inaugurated the third flood in December 1935, in the Centerville Shoestring field in Linn County, injecting water into the Bartlesville sand at a depth of about 400 ft. It is significant that the early "legal" water floods in Kansas were located in different areas, at various depths, and under different conditions.

EXCLUSIVE

At the close of 1942, there were 49 recognized water-floods located in 13 southeastern counties, extending from the Missouri-Kansas boundary westward through Greenwood County and from the Oklahoma-Kansas border northward into Franklin County. The most common oil-producing strata flooded at that time were the Bartlesville, Squirrel, Peru, Wayside, Stray, and Prue. It was not uncommon for cores from these strata to have oil saturations of as much as 60 per cent and oil contents as high as 1000 bbl per acre-foot after economic conditions prohibited further primary recovery. Pointing up the significance of secondary recovery activities in the state, especially in the Cherokee basin and the southern part of the Forest City

basin, is the fact that production has risen from an estimated 5,000,000 bbl in 1942 to more than 10,000,000 bbl 10 years later. For the past 3 years, secondary recovery of oil has accounted for more than 9 per cent of the state's annual production of crude.

As of January 1, 1953, there were 170 projects listed as active in the state, permits for which have been issued by the Conservation Division of the Kansas Corporation Commission. Of the 170 projects listed, 143 reported a total of 5902 wells producing oil by secondary recovery methods, mostly water-flooding, and 4507 wells that were utilized as input wells for injection of a repressuring medium. Of the total secondary recovery projects in the state, 162 are east of the sixth principal meridian, which runs north-south through Wichita. Only six projects were repressuring with gas at the close of 1952.

Greenwood County, as in the past, led all other counties in 1952 in number of projects operating as well as in production attributable to secondary recovery (Table 1). During 1952, 48 projects in Greenwood County accounted for more than 4,500,000 bbl of oil, and 18 projects in Butler County, second largest producer of oil by secondary recovery methods, accounted for more than 1,700,000 bbl. These two counties accounted for more than half the oil produced through repressuring projects in Kansas.

Few water-flood projects have been abandoned and most of the seemingly abandoned fields and parts of fields in the southeast Kansas counties, where the oil production is largely from Pennsylvanian sandstones, may be regarded as potential areas of repressuring. It has been estimated that the average life of a water-flooding project in southeastern and eastern Kansas is about 15 years, and it is believed that the amount of oil recovered by such methods will be about the same as that produced by primary methods.

The following zones, listed in order of their importance, provide the bulk of oil presently produced through secondary recovery method: Bartlesville, Peru, and Wayside. Into these zones is injected the medium of repressuring the oil-bearing strata. In Kansas, the most common medium is salt water obtained from deep formations, especially Mississippian limestones and Ordovician (Arbuckle) dolomites. Other important sources of salt water for repressuring are the Douglas group of rocks, and water produced with oil from the Bartlesville sand. Freshwater sources in Kansas are limited. They are mostly from shallow freshwater wells in stream-valley fills, shallow wells in Pennsylvanian sandstones, streams, ponds, and municipal water supplies. Some secondary recovery projects in eastern and southeastern Kansas that depend on fresh-water sources for their repressuring water have had to close their operations due to the present drought conditions existing in that part of the state.

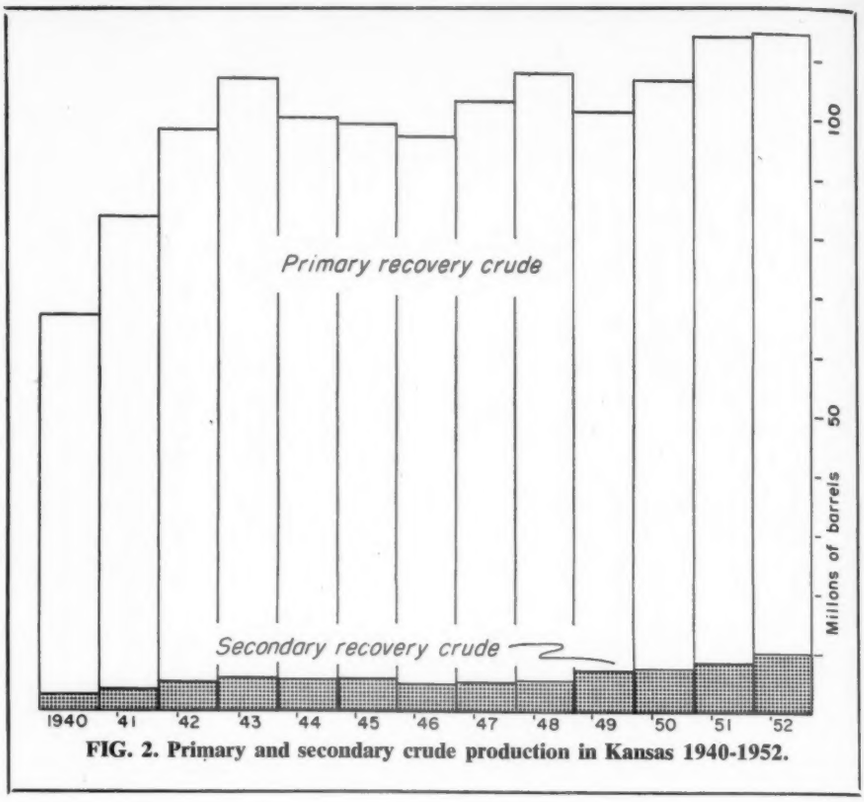

FIG. 2. Primary and secondary crude production in Kansas 1940-1952.

Treatment of water that is injected, whether fresh or salt, is carefully controlled in accordance with laboratory analysis. Users of fresh or surface water are usually faced with the problem of organic matter in suspension, and the growth of algae must be prevented by special treatment, such as using chloride of lime, before the water is suitable for injection purposes. If the water is not treated, organic matter accumulates on the face of the sand in input wells, reducing their intake capacities. Brines, however, normally have fixed chemical composition at the source, and although it is necessary to remove hydrogen sulfide from some, treatment required for a brine before injection in a closed system usually need not be altered once it is developed. Many of the Kansas operations, however, are of the open-type system, which consists of reserve storage tanks, treatment tanks, and settling tanks.

Most water-flood operators inject water under pressure insufficient to lift the overburden. With the recent advent of "fracturing" oil-bearing strata of low permeability, several Kansas projects have incorporated fractured wells in their secondary recovery pro-

The Author

Edwin D. Goebel is in charge of the oil and gas division of the State Geological Survey of Kansas. He has an A.B. degree from Augustana College, and the M.S. degree from the State University of Iowa. A native of Illinois, he has worked with the Missouri Geological Survey. Since coming to Kansas in June 1951 his work has been entirely with the oil and gas industry.

TABLE 1. Oil produced during 1952 by secondary recovery in seven eastern Kansas counties.

County	Number of projects, 1952	Total oil production 1952, bbl	Secondary recovery oil production 1952, bbl	Per cent of total production
Allen	11	609,577	280,872	46.1
Anderson	9	576,882	501,842	86.9
Butler	18	8,164,208	1,708,523	20.1
Greenwood	48	6,834,217	4,528,863	66.2
Miami	9	591,153	527,059	89.1
Montgomery	16	677,827	543,736	80.2
Neosho	9	645,001	469,624	72.8

TABLE 2. Estimated water-flood oil reserves in eastern Kansas counties in 1949.

County	Oil, million barrels	County	Oil, million barrels
Allen	9	Greenwood	93
Anderson	7	Linn	2
Bourbon	1	Lyon	4
Butler	57	Miami	19
Chautauqua	12	Montgomery	14
Cowley	14	Neosho	8
Crawford	1	Wilson	1
Elk	2	Woodson	3
Franklin	13		

jects. The success or failure of such projects has not yet been determined.

Uniform spacing of wells is necessary for maximum oil recovery, and ordinarily wells are arranged in the conventional five-spot pattern of squares, each square having an oil well at each corner and a water input well in the center. A development consists of alternate rows of oil wells and water input wells, the number of wells of each kind being about equal. The five-spot pattern is only approximated in Kansas, however, because the natural pool shoestring pattern does not everywhere permit geometrical development.

Table 2 shows estimated reserves of oil in eastern Kansas counties believed to be recoverable by secondary recovery methods. The table is based primarily on Sweeney's[3] (1949) estimates. Dahlgren[1] (1951) estimated total recoverable reserves by secondary recovery methods as of January 1, 1950, at more than 238,000,000 bbl — more than 20 years' supply at the present production rate, or two years' supply of the state's total crude production.

Many areas of primary production of western Kansas are or soon will be approaching their economical end. Several fields of western Kansas are being studied for possibility of repressuring. Perhaps we will observe a further slow movement of secondary recovery methods toward the west as has been true since the inauguration of the methods in southeastern Kansas.

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* * *

Drilling Costs Mount As Drilling Depths Sink

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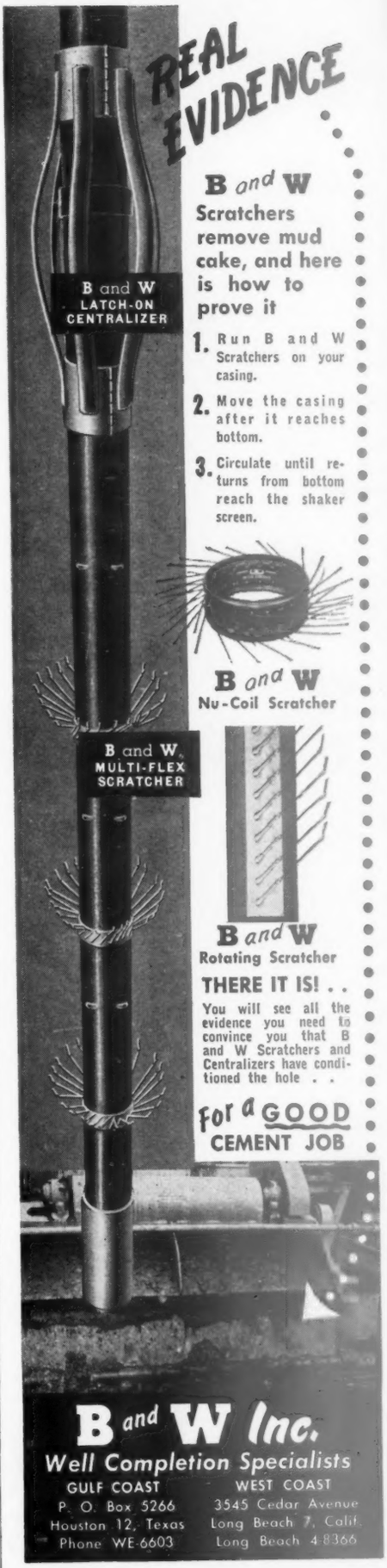
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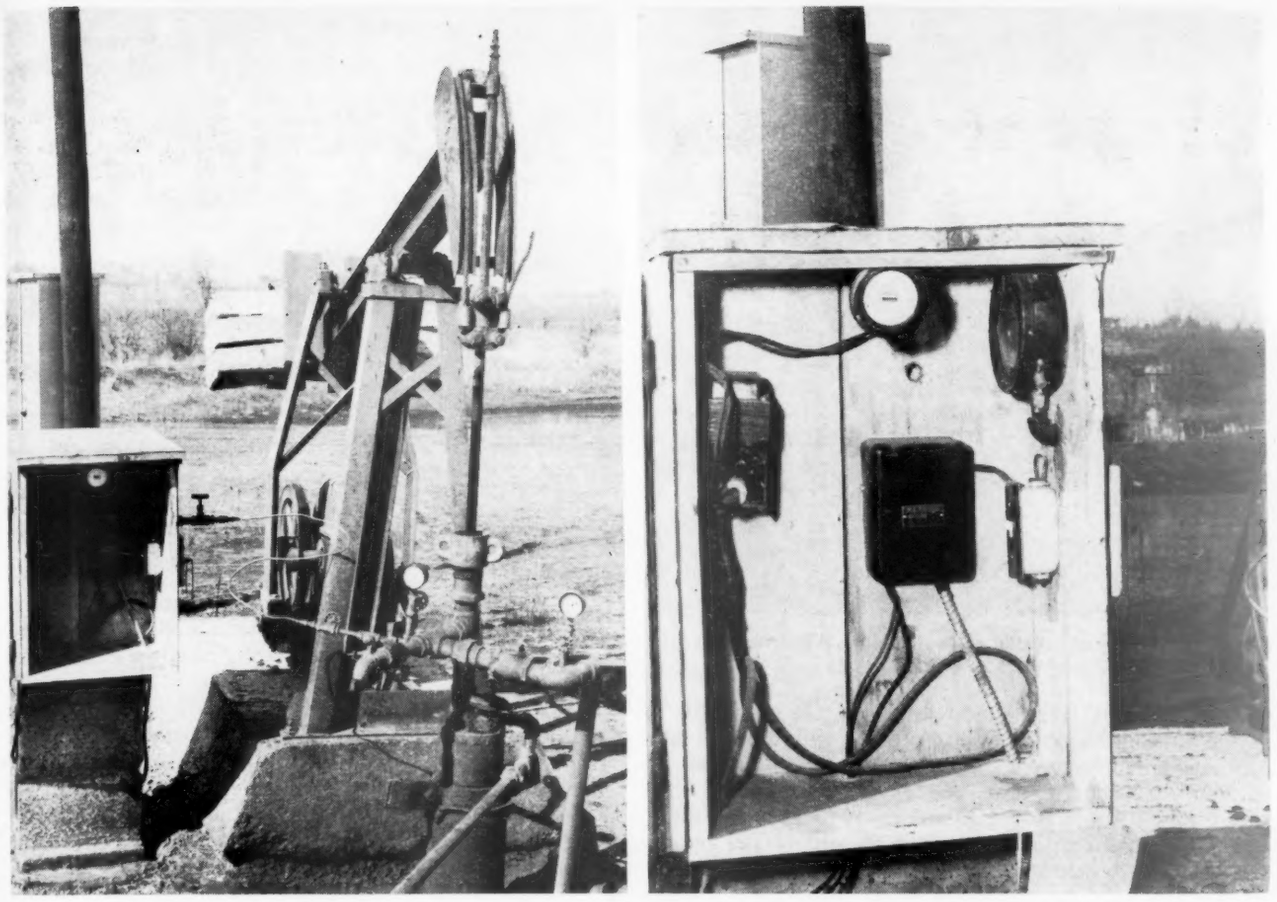

Installation of surface control equipment, Maracaibo Oil Exploration Corporation No. 2-10 North Cone.

AUTOMATIC PUMPING PROCEDURE

WATER FLOOD AREA IN EASTERN KANSAS

R. F. LOLLAR*

THE principle of automatic pumping of an oil well as described in this paper was planned, developed, and placed in operation in the fall of 1951 on leases now operated by Maracaibo Oil Exploration Corporation in Franklin County, Eastern Kansas. Decision to carry out such procedure was made as a direct result of the belief that ordinary time clock control was not sufficiently satisfactory to maintain a minimum amount of fluid against the sand face at all times. Further, it was thought that, under such cyclic methods, the element of error in human judgment was too great a risk to undertake if it could be established that the element of such was commensurate with the gain.

By virtue of the fact that wells were pumping and not flowing, it was a foregone conclusion that our efforts were directed to minimizing the average head of fluid in the well bore; and although a fair performance was available by use of the regular methods of pumping, it was felt that a perfect performance was as easily obtainable under automatic methods. To this end we worked in an attempt to keep an oil well completely pumped off at all times and yet not over-pump the well to the extent that cut oil or wasted power costs would result.

As recently published, the experiment was originally conducted on the corporation's Moherman farm east of Ottawa, Kansas, and is supplemented herewith as to innovations added to the original experiment, together with factual results not available at that time. The experiment has now been proved to be a complete success and satisfactorily justifies its original intent.

In general, as stated, its purpose is to disallow any accumulated head of fluid to stand above the sand, thus discouraging the free flow of oil and water

*Maracaibo Oil Exploration Corporation.

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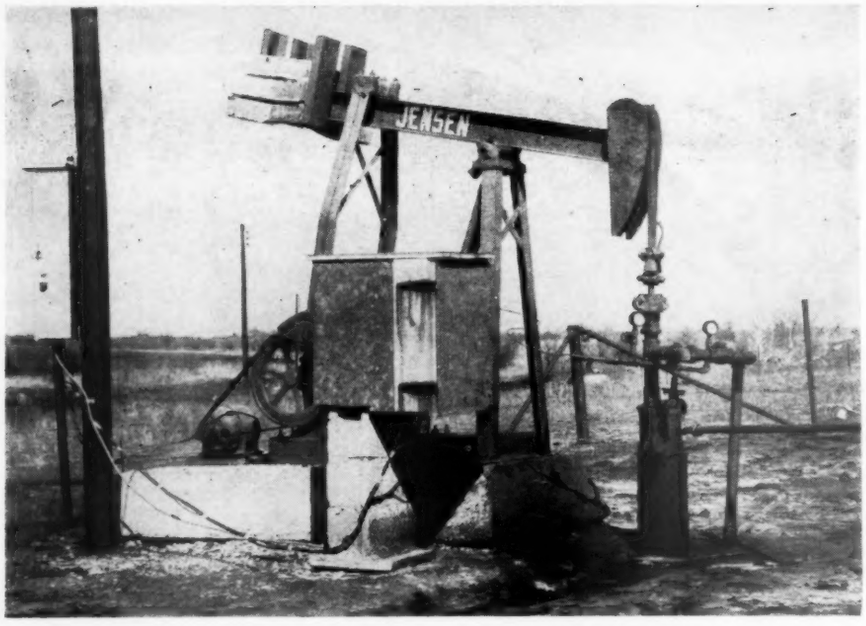


Surface suspension of parallel control tubing. Well No. 2-10 North Cone.

into the well bore. If, by such reasoning, the possibilities of the well to produce a maximum amount of oil in a minimum amount of time are enhanced, then it could be considered to have served its purpose. Results indicate that this is being accomplished. Additionally, the procedure has also resulted in the following benefits:

1. *A reduction in pulling costs and replacement expenses*
2. *Elimination of production of a cut or emulsified oil to the extent where an additive is unnecessary*
3. *More efficiency in power costs*

The method of operation is based entirely upon the rise and fall of fluids within a string of one-inch pipe, or smaller, open end on bottom, and the corresponding fluctuation of pressure resulting from such activity. A diagram of the piping system shows the bottom of the supplemental string of pipe to be only a few feet below the working barrel. When the well is not pumping, fluids will rise inside the hole as well as in the one-inch pipe, and pressure thus created within the one-inch string activates a Mercoid control, energizing, in turn, a Mercoid relay that is connected directly to the magnetic starter. As the well then begins pumping, height of the fluid decreases in the well to a level where the pressure on the one-inch string is reduced by two ounces, and the Mercoid is then deactivated and the pumping of the well is automatically discontinued.

Fluid levels within the well can be established by the maximum air pressure obtainable on the one-inch string, and the working levels can be controlled, pumping wise, at any desired point regardless of the working barrel's placement. Although the diagram will illustrate the barrel's placement at the top of the sand, it should be mentioned that it is the company's practice to keep the sand bathed in oil rather than water and that such procedure has no bearing on any of the automatic features.

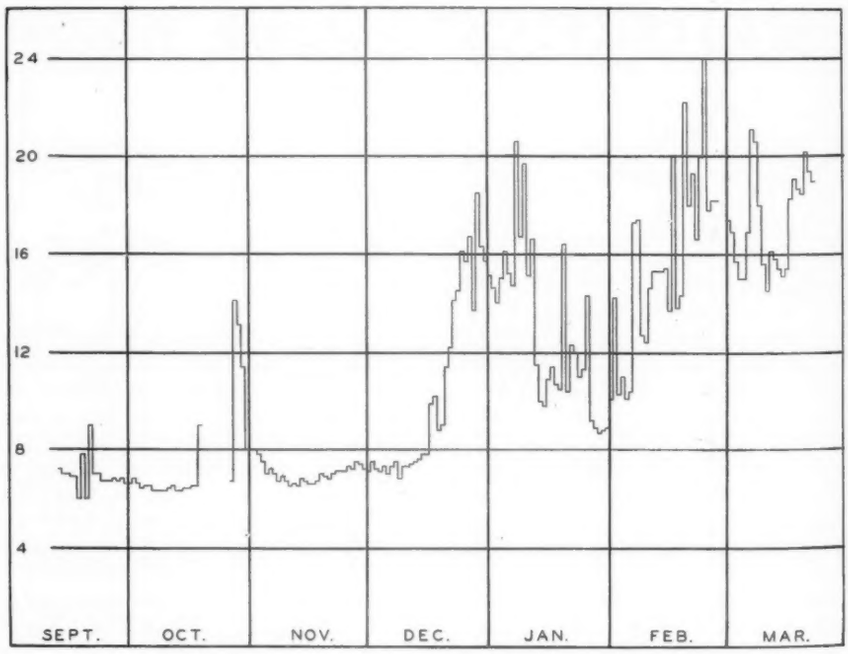
Experience obtained in the original installation dictated the advisability of complete enclosure of Mercoids on a solid foundation to prevent vibration caused by wind from energizing the Mercoid and resulting in palpitation. Also, a running time meter was installed so that the pumping hours, on a daily basis, could be recorded and/or used to correlate with many factors regarding conditions of the well. Any variation in efficiency or quantity of fluid pumped is immediately detected, both of which are of particular importance to the operator and neither of which is so readily accessible under any other pumping conditions.

Costs of installation, excluding labor, may involve the following items:

X ft — 1 or ½-in. pipe
1 — pressure gage in ounces
1 — pressure gage in pounds
5 — ¼-in. throttles
1 — ordinary tire pump valve
4 ft — copper tubing
1 — Mercoid control
1 — Mercoid transformer relay
1 — running time meter
1 — 440 V-110 V transformer
1 — usual switch box controls

Since the original experiment, Maracaibo Oil Exploration has installed other automatic wells and on various leases. In every case, the procedure has been, and continues to be, successful.

The first well now has operated satisfactorily for 18 months and required one pulling job, for cups only, in that length of time. Prior to automatic installation, the pumper in charge, using a time clock, has arranged for the well to pump 16 hours a day on 2 cycles of 8 hours each. After the well was placed on automatic, its running time was decreased to 5.5 hours a day on approximately 70 cycles in 24 hours. Admittedly, the well was previously being over-pumped, but it was never known until the change over to automatic pumping that it involved such substantial proportions. During the period of this well's automatic life, due to its having been a comparatively old well,



Well No. 2-10 North Cone pumping time in hours per day.

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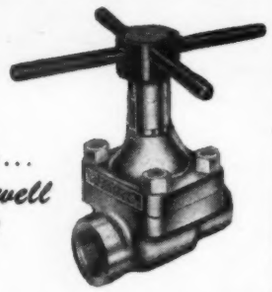

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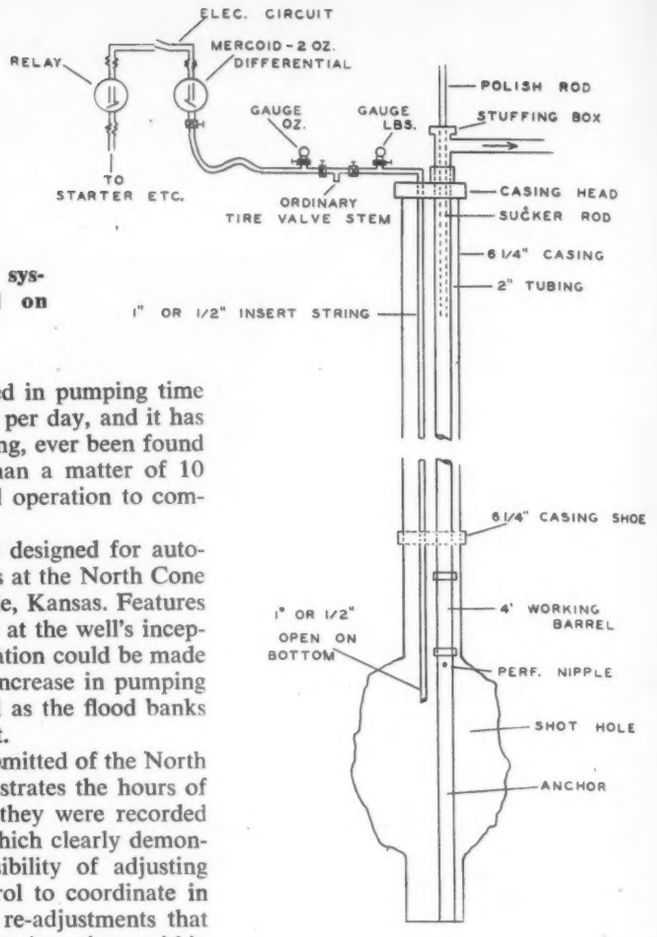

Diagram of piping system as employed on North Cone lease.

it has seldom varied in pumping time from the 5.5 hours per day, and it has at no time, on testing, ever been found to require more than a matter of 10 minutes on manual operation to completely pump off.

The second well designed for automatic pumping was at the North Cone lease near Wellsville, Kansas. Features were installed here at the well's inception so that observation could be made in relation to the increase in pumping time of a new well as the flood banks encroached upon it.

An exhibit is submitted of the North Cone well that illustrates the hours of pumping time, as they were recorded on a daily basis, which clearly demonstrates the impossibility of adjusting a time clock control to coordinate in any way with the re-adjustments that were occurring at various times within the reservoir surrounding the well. This well, too has not required, on testing, more than a few minutes to completely pump off and has continuously produced oil that is entirely free from basic sediment content.

Although the North Cone automatic well has required new cups on one occasion, it has produced a considerable volume of fluid during the period of its operation. There is no reason to believe that said well should have been any more or any less prolific than any of the other wells on this lease, and yet it has produced, and continues to produce, more fluid than any of the several other wells in this entire area. Its peak crude oil production was substantially higher than any of the other wells, having produced crude oil at approximately twice the highest rate than theretofore had been either experienced or anticipated.

Summary

Results of automatic pumping as we have observed can be summarized as follows:

1. *Water can be kept off the sand face so that the possibilities of water blocking are eliminated.*
2. *Fluid levels can be maintained at a minimum, permitting unrestricted flow of fluid into the well bore.*
3. *Energy requirement of electrical power is not wasted.*
4. *Production of cut or emulsified oil has been eliminated to the extent that emulsion breaking additives are unnecessary.*
5. *Pulling and replacement costs have been reduced.*

Our experience appears to indicate completely successful results in automatic pumping procedures and justifies in every way our attempts to eliminate, with certainty, the element of human error in a most vital phase of the water flood operation. ★ ★ ★

★ ★ ★

Summer Gas Study

Four college courses designed as refreshers for gas industry employees will be offered at the Institute of Gas Technology, Chicago, during the summer session. The four subjects are: Natural Gas (June 14-July 2); Transmission and Distribution (July 6-23); Peak and Base Load Natural Gas Substitutes (July 26-August 3), and Utilization of Gaseous Fuels (August 26-September 3). Courses are at college senior level and may be taken for academic credit by qualified undergraduates. Others will be awarded certificates upon successful completion. Any or all of the courses may be taken by enrollees.

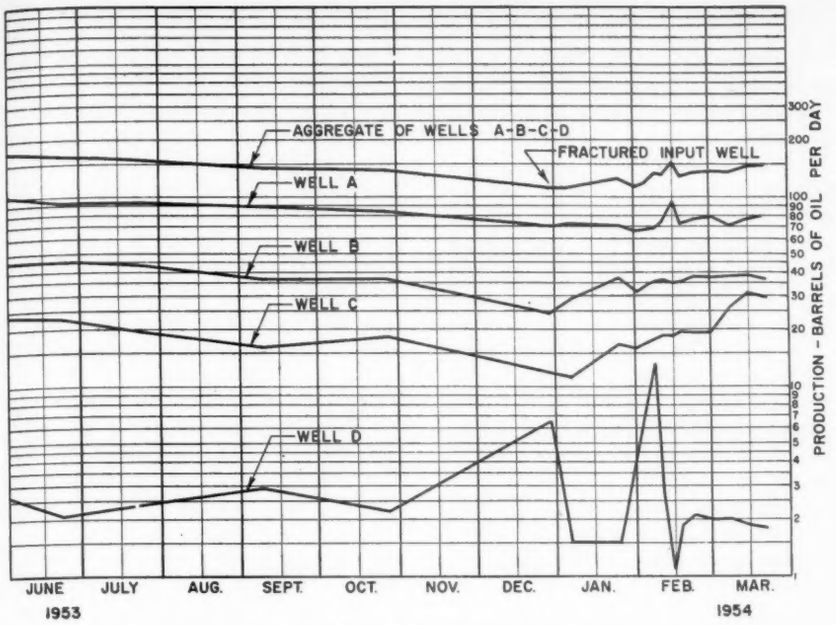

FIG. 1. Oil production history of wells offset to water input wells.

Fracturing in Shallow Eastern Kansas Sand

FRANK W. KAUL

ALTHOUGH hydraulic fracturing was offered commercially in 1949 as a well completion method, it was not used in the shallow Eastern Kansas sand wells to any large degree until fracture treatments with gelled hydrocarbons were successful, but due to the excessive cost of the large volume treatments that were needed, well operators were not attracted to use hydraulic fracturing as a standard completion method until it was found that these low pressure, tight sand wells could be economically completed using sand and oil mixtures.

To date more than 4000 wells in this area have been completed with fracture treatments. Most of the first of these were completed using small size treatments of 1000 gal or less of sand laden fluid and not exceeding one pound of sand per gallon. From the beginning there has been a tendency to increase the size of the treatments. This is still continuing.

This was originally a cable tool country and most of the drilling is still done with cable tools. However, wells are successfully completed using both rotary and cable tool drilling methods.

Some wells are completed for fracturing by cementing 2-in. tubing in the sand on a packer, generally leaving the best of the pay sand exposed below the packer. Most of the wells are finished conventionally, using casing for production.

In some areas, notably in Montgomery and Labette counties, if the sand section to be fractured is unusually thick or if a shale break disrupts vertical continuity, many operators will fracture the well two or more times. This procedure has been very successful and can usually be accomplished economically in one operation. This is commonly done using two separate techniques or a combination of the two.

One method is to set pipe in the top of the sand and to multiple fracture the well by running successive stages of sand and oil mixtures, each stage followed by temporary plugging agents to create new fractures.

Another method very commonly used is to set pipe through the sand section and perforate a foot or two in the middle of each zone. A packer is set between the perforated zones and each zone selectively treated, one down the tubing below the packer and one down the annulus between the tubing and casing. The annulus and tubing pressures are both closely observed throughout each treatment and if communication between the zones is noted, temporary plugging agents can be used to stop inter-communication of the two zones.

On new wells the initial break down pressure, preceding sand injection, generally exceeds the overburden pressure and is in the range of 1000 psi to 2000 psi. Frequent exceptions to this are the Peru sand in Chautauqua County, and the Bartlesville and Cattleman sand of Greenwood County, which often break down at very low pressures. As a whole, the wells usually treat easily at fairly low pressures of 400 psi to 1200 psi during sand injection.

Ordinarily, treating pressures do not indicate that multiple fracturing occurs during treatment unless plugging agents are used.

Peculiarly, some of the poorest looking sand sections with very small natural shows of oil often turn out better than wells with a good natural showing in the same pool. This may possibly be explained by considering that in many instances new wells are drilled in old fields that have been drilled once before and occasionally twice, the sand zones having good natural permeability may have been previously drained and pressure depleted to the point that although capable of showing good free oil naturally, there is not enough formation pressure left to enable the well to sustain itself after the first flush production and it will show a very fast decline. New edge wells or even wells five spotting old production may encounter tight sections which were never depleted by previous production attempts.

Most new drilling in the Eastern

The Author

Frank W. Kaul is the assistant division engineer at El Dorado, Kansas, for the Halliburton Oil Well Cementing Company, Wichita division.

A graduate of Kansas State College, he has been with Halliburton since 1947.

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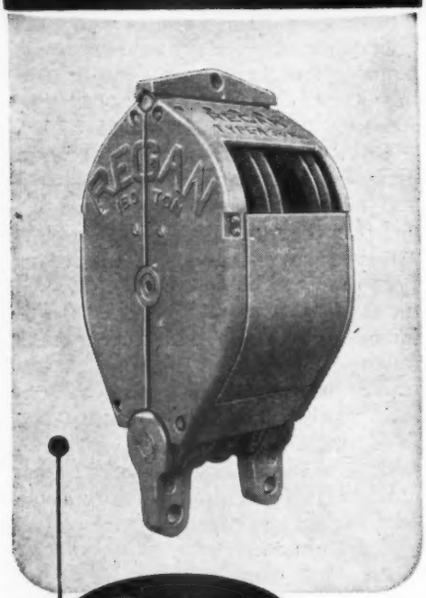

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Kansas shoe string sands either develops or extends old fields which were formerly too marginal to produce. Many operators are having good success in areas where oil shows were noted while drilling for gas in previous years.

Numerous problems are encountered when drilling in an old field that has not been properly plugged out. One is water invasion into the pay section from upper water sands via the old holes. The degree to which this may take place is dependent on the tightness of the sand or its ability to take water. Another is in finding all of the old locations to avoid crowding an old hole with a new well. Wells which are drilled close to an abandoned well or old dry hole are generally fractured with relatively small size treatments of 1500 to 2500 gal of sand laden fluid. It is best to stay at least 200 or 300 ft from any old hole, if possible.

In some fields the high viscosity of the formation crude is a problem in itself. Settled production is not generally large where the combination of low bottom hole temperatures, high crude viscosity, and low gravity are encountered. However, this crude is marketable and the wells have extremely good longevity.

Sometimes sand pays are encountered that occur either as very fine layers of sand and shale or as a badly broken section of sand and shale. These wells are difficult to complete successfully and thus far seem to have responded best to multiple fracturing. Examples of this condition are common to the Wiser sand in Southeastern Kansas and the Squirrell sand in Anderson and Lynn counties. These wells may respond better to vertical fracturing treatment if this process develops successfully. In the same category are sands of very low natural horizontal permeability on the order of one to five md. Although not enough attention has been given to vertical permeability in the area, it seems likely that vertical drainage into the fracture in these cases is slow and this is evidenced by good flush production immediately after fracture treatments and a rapid decline to a low daily production rate. If these tight sands have some solubility in acid, small acid treatments injected ahead of the sand laden fluid have helped to stabilize production by increasing vertical permeability and improving a poor drainage condition.

Originally it was assumed by many producers, familiar to secondary recovery operations, that well completions utilizing hydraulic fracturing would preclude the possibility of successful water flooding programs on the same property. Indications are that this is not always true. Quite a number of oil wells are being currently fractured in active water floods. A few of these have resulted in large increases of produced fluid with very high water ratios suggestive of channeling from input wells, but the majority of wells treated in active floods have responded with increased water production fairly well in line with increase in oil. In closely spaced properties the fracture treatments are often limited in size to prevent possible by-passing of oil during final stages of the flooding program.

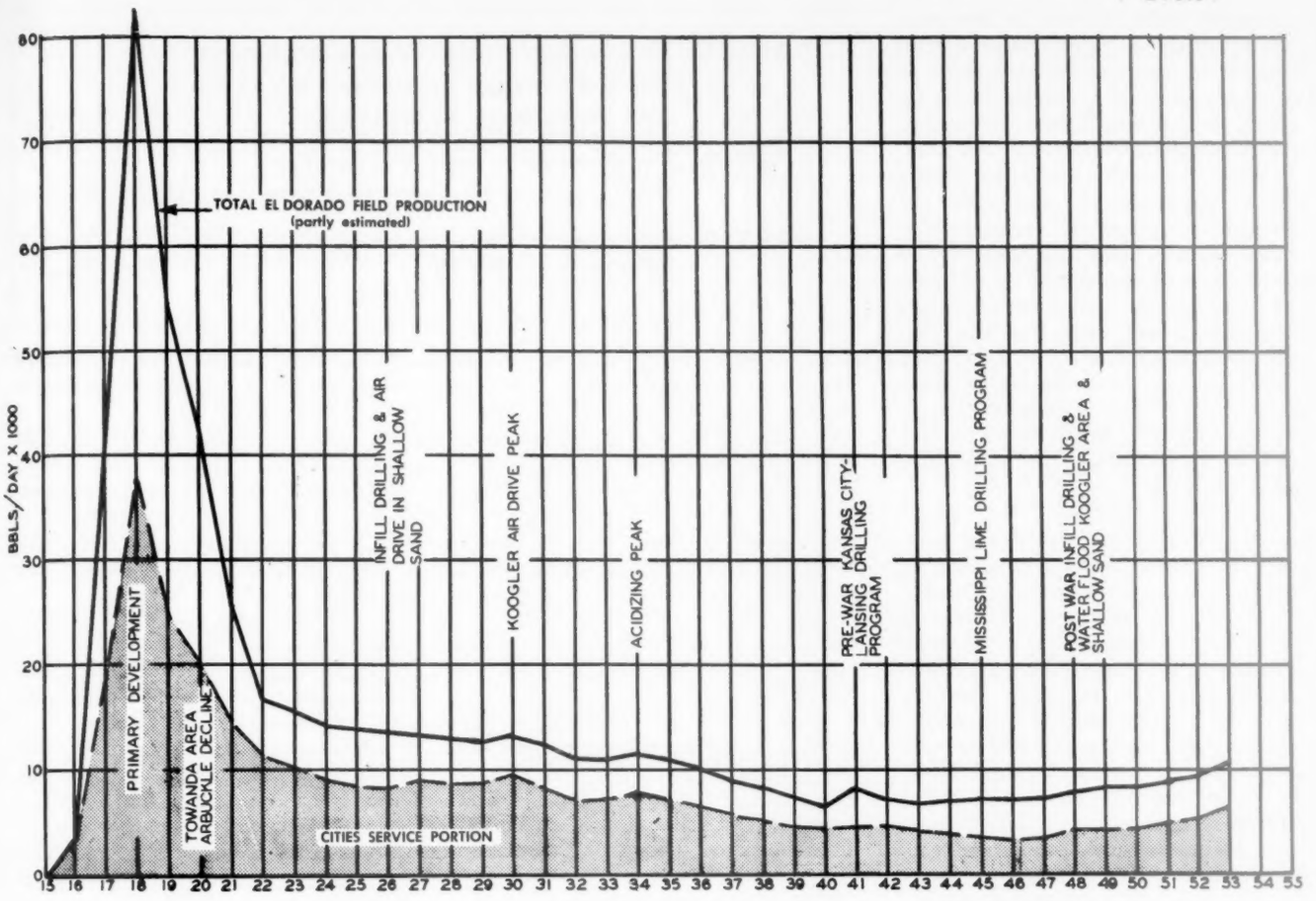
Until now, wells which have been chosen for fracture treatment in water floods are generally wells which for one reason or another have not shown suitable response to flooding. Frequently they are on the verge of being plugged. One producer, operating extensively in Allen and Anderson counties, fractured eight oil wells in active flood projects with only one outstanding success. It must be taken into consideration, however, that none of these wells were showing proper response to flooding before fracturing treatments were tried. Fracturing in active water floods has been successful in secondary recovery projects in the Bartlesville sand in Neosho and Greenwood counties.

Of particular interest are the results obtained from fracturing a water injection well in the Bartlesville sand on a water flood unit in Greenwood County. The need for higher injection rates on certain input wells was emphasized by the probable presence of precipitates in the well bore, which have occurred by the mixing of Douglas and Bartlesville waters. To this end, an input well was fractured with 2500 gallons of sand laden fluid. This input was 660 feet distant from each of four surrounding oil wells and a total of over 300,000 bbl of water had been injected into it since its conversion from an oil well in December 1949. After the fracture treatment in December 1953, water injection increased from 136 bbl per day, at 867 psi average injection pressure, to 305 bbl per day in January 1954, at 704 psi. In March this well took 412 bbl per day at an average pressure of 921 psi.

No channeling of injected water directly from the input well to the four offsets has been noted and increases in produced water have been consistent with actual oil production increases. The accompanying graph, Fig. 1, illustrates a satisfactory response in oil production to the increased water injected.

* * *

The tonnage that crude oil and natural gas produced in the nation last year was greater than that of any other single commodity, eclipsing the total for iron ore and steel by about 250 per cent.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KOOGLER AIR DRIVE PEAK
ACIDIZING PEAK
PRE-WAR KANSAS CITY-LANSING DRILLING PROGRAM
MISSISSIPPI LIME DRILLING PROGRAM
POST WAR INFILL DRILLING & WATER FLOOD KOOGLER AREA & SHALLOW SAND

EL DORADO FIELD — PART 2

Engineering and Production Problems

E. E. FUNK and W. M. CANTRELL

RAPID war time (World War I) development of the El Dorado field left a large field producing at a wide open rate from which many difficult production problems were certain to arise. The first problem was salt water, which led to three big problems: Exclusion of the water, emulsion, and corrosion. Although these problems occurred simultaneously, engineers worked on them in the order mentioned. With support by industry, the Bureau of Mines worked extensively on these problems along with operators in the field.

The big pay zone was the "Deep" or 2500-ft zone. This was the formation labeled "Stapleton" sand in the discovery well, now known as the Simpson sand. Although not originally distin-

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The Authors

W. M. Cantrell E. E. Funk

E. E. Funk is a secondary recovery engineer for Cities Service Oil Company in Bartlesville, Oklahoma. A graduate of Kansas State College, he joined Cities Service in 1936 in the production laboratory in Kansas. He subsequently served as district production engineer at Oil Hill and Madison, Kansas. After a time in the Navy, he returned to Cities Service as assistant secondary recovery engineer in 1946, and since 1948 he has held his present position.

W. M. Cantrell is division engineer in Cities Service's oil production division at El Dorado, Kansas. He joined Cities Service's Junior Engineer Training School in 1919 after serving one year in the U. S. Navy.

After completing his junior engineer training, he served as roustabout in the El Dorado field and then was assigned as operator at the El Dorado electrical sub-station. He then served as production clerk, assistant district superintendent, construction foreman, and district engineer. In 1938, he was appointed division engineer for East Kansas. He has been in charge of most of the secondary recovery work for Cities Service in East Kansas.

guished as different from the Simpson, another deep pay zone, more general than the Simpson sand, was known as Siliceous lime and is now generally referred to as Arbuckle lime. Two rather confusing performances were observed. First the big wells (10,000 to 25,000 bbl per day initial) did not "gush" but seemed to flow out the casing head a solid stream of almost gas-free oil. The appearance of water with this flowing oil soon revealed that pressure was due to a natural water drive. A field with a strong natural water drive was a rare experience for oil producers in those days. At the same time other "deep" wells made some gas with the oil and declined in production with very little water showing.

A chemical laboratory was established by Cities Service in 1918 to work on this problem along with other related problems. The laboratory quickly developed the ability to distinguish upper water which entered a few wells through faulty casing. The first conclusion was that the water that increased as the oil declined was chiefly bottom water existing at a certain subsea depth or a certain distance below the top of the pay. There followed a number of attempts to plug off bottom water by driving steel cuttings and lead bottom hole plugs. By and large these attempts resulted in reduced fluid production with some reduction in oil along with large but more or less temporary reduction in water. The subsequent conclusion was to accept some water production that generally increased as the oil decreased. Considerable study was also made as to the merit of skimming type operation, but severe corrosion of casing below the skimming point soon ruled out skimming as a general practice. Through the years, there have gradually developed a number of facts concerning the water in the "deep" pay.

a. There are several different pay sections in the deep horizon. Specifically, some wells have Viola lime which has a partial natural water drive and Simpson sand with only gas in solution drive both just above the Arbuckle. The Arbuckle has zones of porosity with widely varying permeability, making it possible to find water above the oil. Even today a virgin Arbuckle oil pay is occasionally found.

b. The Arbuckle has only a slight formation dip. Therefore the strong water movement in all zones of permeability is continually relocating the oil so that infill wells near depleted and abandoned locations frequently came in as good producers.

c. Any Arbuckle well will eventually make water, but it may continue to produce paying quantities of oil for a long time if enough water can be withdrawn to keep the well pumped down.

d. Many of the early drilled wells that merely "scratched" the top of the deep pay have found additional oil through deepening. Also, a bold penetration (250 ft) may find oil below water in the Arbuckle and some successful exclusion of water is now pos-

PART 1—El Dorado Field Was Classroom for Advanced Teaching of Modern Petroleum Technology ..... Page E-2

PART 2—Engineering and Production Problems in El Dorado Field ..... Page B-57

PART 3—Secondary Recovery in the El Dorado Field ..... Coming

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sible through the diesel oil-cement squeeze technique.

Salt Water Disposal

Salt water produced from the deep wells through the years has been an increasing disposal problem. For years there was no underground disposal law and the water was allowed to follow natural surface water drainage. Many damage claims were paid by producers in the El Dorado field. The Kansas Board of Health in later years has been reasonable but firm in working with the operators to provide satisfactory disposal. To date it is believed that no oil wells have been abandoned for lack of salt water disposal facilities. Several salt water disposal systems with disposal wells are now in operation, but the bulk of the salt water is now being gathered and used in waterflood of other producing horizons in the El Dorado field (See later discussion).

Emulsion Problem

The second big production problem in the El Dorado field was related to the water production. The deep wells produced relatively heavy oil (33 API), which often came out badly emulsified with water.

The first attempted solution was to install a steaming plant on each lease. Steam was passed through coils in the treating tank (also called gunbarrel or separator). Heating the oil served to speed the water separation but temperatures used were so high that vapor loss was tremendous and certainly not appreciated by refiners of that time. Another problem was the large amount of heavy emulsion necessarily cleaned out of stock tanks and run to pits. Combustion was difficult and incomplete so that more and more of the land was being used for burning pits.

After some laboratory work, it was concluded that a much more effective separation could be accomplished in one large plant. In 1921 Cities Service built its Boyer dehydrator to handle production from all of its leases in the El Dorado field. Use of a central plant required special tests to properly credit production to royalty owners. A method was perfected by the Bureau of Mines sampling each tank of oil and physically determining water content through a laboratory distillation procedure. As the oil was produced, free water was separated at the lease tank battery, but all oil and emulsion were pumped to the dehydrator.

The Boyer dehydrator made use of three practices:

1. Heating as was previously done on individual leases, but with heat exchangers to reduce fuel requirements and vapor loss.
2. Settling with the aid of caustic as a coagulating agent in a process patterned somewhat after methods for clarifying water.
3. Centrifugal separation using cream separators on the concentrated emulsion left from the heating and settling.

During the operation of the Boyer dehydrator, extensive work was done toward developing chemicals to break oil field emulsion. The Tretolite people worked closely in perfecting their saponified soaps and Cities Service developed a non-water softening treating chemical called "Pronox." In all cases the chemicals served to reduce surface tension in the emulsion.

By 1928, the emulsion problem had declined to where operation of the central dehydrator was no longer feasible. The better treating chemicals were chiefly responsible for overcoming the problem, but it was also evident that emulsions were less difficult with the much larger per cent of water then being produced. At this time emulsions were broken by adding chemicals down the hole to the worst wells and also at the gunbarrel. Only a few leases were equipped to heat the oil in the gunbarrel and a portable heater was used to break tank bottoms or clean up a full tank of oil when troubles arose. In general, this practice continues today except

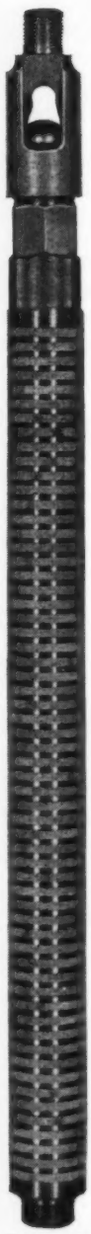

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TABLE 1. Analysis of Arbuckle Water from Cities Service, Knox No. 25, Butler County, Kansas.

		Parts per million
Iron	(Fe)	25
Strontium	(Sr)	171
Calcium	(Ca)	1,398
Magnesium	(Mg)	313
Sodium	(Na)	11,054
Bircarbonate	(HCO_3)	322
Sulfate	(SO_4)	1,357
Chloride	(Cl)	19,330
Silicate	(S_iO_2)	6
Gas Acidity as	CO_2	15
Hydrogen Sulfide	(H_2S)	134

Swedish steel strip test in stoppered bottle:
73 mg loss per 100 sq cm in 10 days
213 mg loss per 100 sq cm in 30 days
Deposit of iron sulfide on both strips.

that the effectiveness of the emulsion-treating chemicals is being continually improved.

Corrosion Control

A third big production problem associated with the water was corrosion. The salt water from the Arbuckle zone (Table 1, water analysis) contains rather large quantities of dissolved hydrogen sulfide. This water caused extreme corrosion of tubing, rods, and casing. It is reported that at one time there were tubing strings that lasted only 30 days. The chemical laboratory worked on this problem from its beginning. An attempt was made to use zinc electrodes in the well to sacrifice the zinc rather than steel equipment. One attempt used zinc doughnuts around tubing and working barrel. Along this same line, wood insulators were tried to prevent the tubing from touching the casing. The first really good remedy was a down-the-hole chemical treatment that was patented about 1926. The chemical treatment consisted of caustic soda solution with varying amounts of tannin. The caustic counteracted the hydrogen sulfide acidity and the tannin served to keep the side products — calcium and magnesium carbonates in suspension and thus avoid bad scale formation on equipment.

For about 20 years Cities Service maintained three chemical mixing plants where solid caustic and tannin were received in carload quantities. The two ingredients were put into solution and hauled by tank truck to individual wells throughout the field — including many wells of other operators. Each well so treated had a chemical drum placed near the well-head from which chemical was mechanically pumped into the annulus between casing and tubing. Short time wells were treated by hand. Well service crews of necessity wore rubber coated gloves and goggles and the standard first aid kits included acetic acid solution to neutralize any caustic which might get on a worker's body. During the last few years that caustic was used, it was purchased in tank cars in solution. To control this corrosion prevention treatment, a laboratory crew continually ran partial water analyses on water samples from the wells treated or proposed for treatment. Detail cost records showed a tremendous saving through this chemical treatment. Eventually, the tubing string life on the most severe wells was stretched to at least 2 years.

Beginning in the early 40's many other types of chemicals of the inhibitor type have come into general use which gave equally good corrosion control. One material used quite extensively is formaldehyde. Most of the corrosion prevention chemicals are sold under a trade name and used at rates recommended by the manufacturer. The caustic type treatment is no longer used since other available materials of the inhibitor type are less dangerous, less likely to form scale and are somewhat cheaper. Cities Service has developed corrosion prevention chemicals of the inhibitor type, both oil soluble and water soluble.

Corrosion in the El Dorado field was also destructive of lead lines and metal tanks. As the treatment for tubing protection also helps the lead lines internally, the only other problem with lead lines was external corrosion. Efforts have been made from time to time to cathodically protect lead lines

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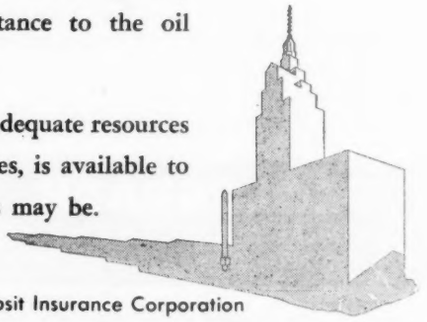

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and other buried lines, but in general the only practice is to externally coat in known and obvious hot spots. Initially, all tanks were bolted steel tanks. Internal corrosion of tanks in the batteries was severe especially on the bottom and deck. The first step in solving tank corrosion was to replace steel gunbarrels with wood tanks. This proved so effective that wood stock tanks were used next. In using wood tanks, it became necessary to improve the technique for setting up tanks which would be tight enough to hold both oil and vapors. Between 1923 and 1926 Cities Service replaced all the steel tanks with wood tanks having a deck that was to be always flooded with water. To prevent evaporation and drying out of the wood tanks, sheds were built over all wood tanks. Many of these wood tank batteries with sheds are still in use today. A few welded steel tanks have been installed over the El Dorado field in recent years, but corrosion is still a source of trouble even on ¼-in. thick steel.

As the flowing life of wells in the El Dorado field was short, the wells were soon put to pumping. An interesting evolution of pumping methods has occurred. Initially the deep pumping wells were equipped with wood standard ends powered by steam engines. The one gas pay in the El Dorado field depleted quite rapidly. As the steam boiler used gas for fuel, the fuel problem was difficult. With a utility background, it was only natural that Cities Service turn to electricity. Some other operators also used electricity, while others managed to get by on available gas. When electricity was first used, pumping units as we know them today were not available. The old steam powered standard ends were equipped with 550 and 1100 rpm motors and counter shafts in place of the steam engines, or gas engines. The counter shaft was needed for speed reduction.

Motors were dually rated 15 to 30 hp with a resistance grid and controlled to yield flexibility. The flexibility was such that this same power source was used to pull tubing and rods in servicing the well at 1100 rpm and to pump at 550 rpm. Obviously, this use of electricity was inefficient but the electric rate was quite favorable. Cities Service had such a large requirement for electricity that they purchased at main line voltage, 60,000 v, operated a central substation and transmitted at 12,000 v through their own primary distribution system and reduced to secondary voltage 440 v in transformer banks throughout the field. To assure ample electricity, Cities Service encouraged the construction of a high voltage transmission line which starts in the Southeast corner of Kansas (near Joplin, Missouri) and terminates in the El Dorado field.

Central powers with wood band wheels were used very early to operate pumping jacks on the shallow wells. For energy the central powers were driven by gas engines. Because the shallow sand was developed more slowly, many of the shallow powers were built when gas was scarce and therefore were powered from the start by electric motors of the same size as used on the deep well standard ends. In the search for efficiency in pumping the deep wells of smaller capacity, there was a swing to the use of central powers here also. These deep well powers were driven by gas engines usually rated 50-60 hp. About 1928, ample gas became available from the Cities Service Company so that it was never necessary to use electricity to drive the heavier deep well powers.

Many of the motor driven standard ends and motor or gas engine driven central powers remain in operation today. Since about 1940 nearly all new drilled wells have been equipped with electric motor driven pumping units. With the large scale advent of waterflood, many old wells have had the pumping jacks replaced with electric powered pumping units. * * *

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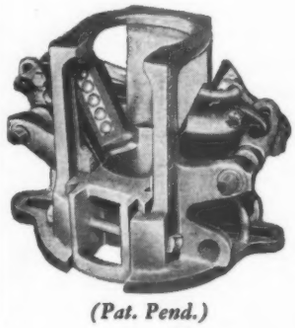

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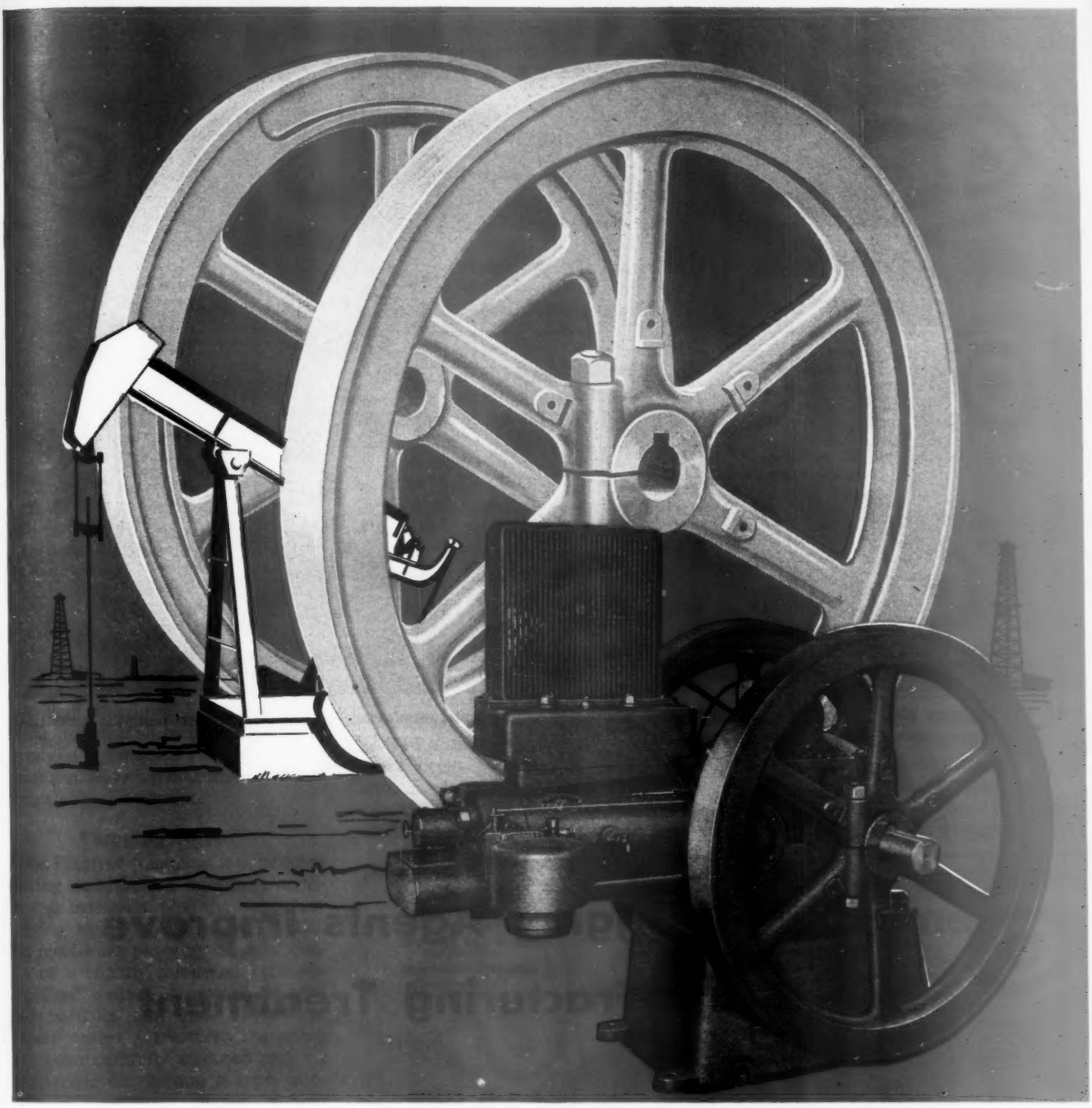

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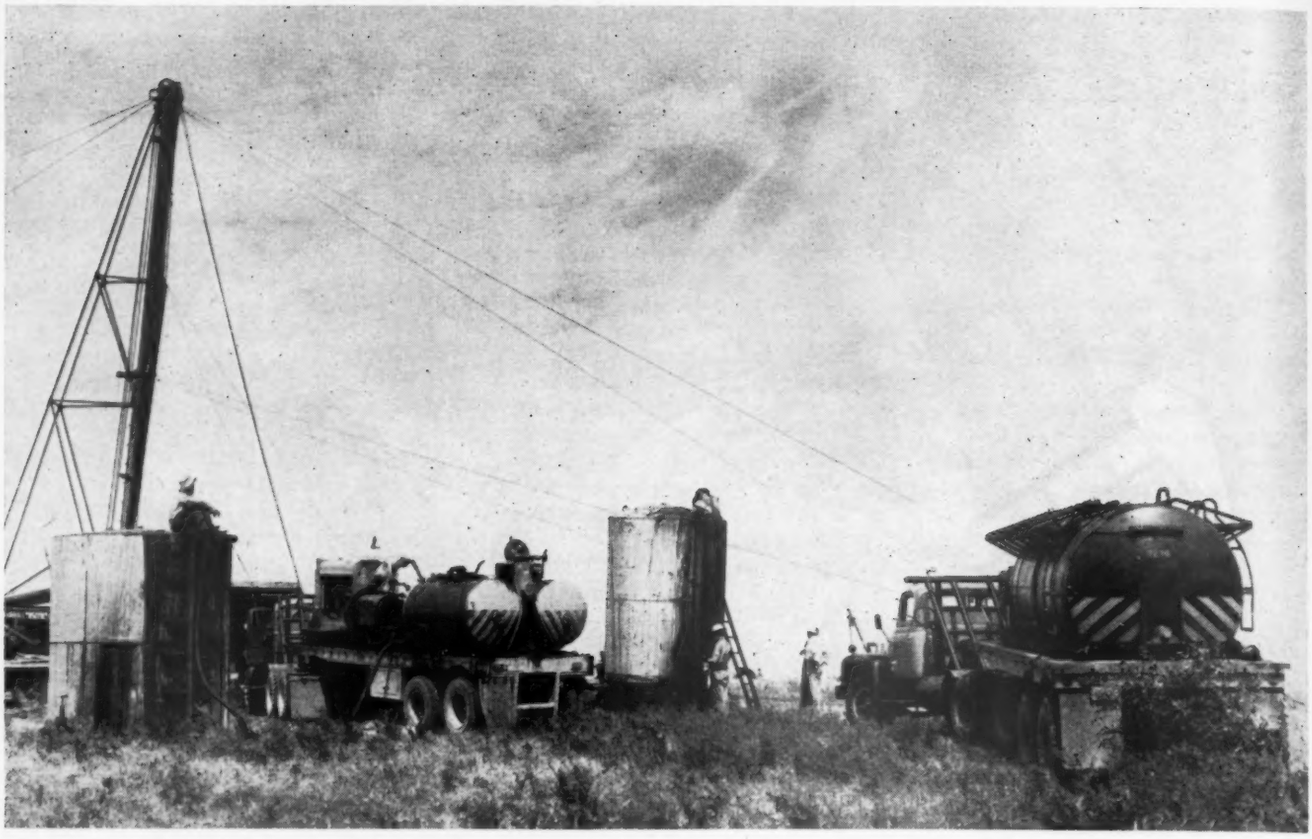


FIG. 1. Temporary plugging materials are mixed and applied at the well site, employing the mobile transport-pumping units used for conventional fracturing treatments.

Increase Permeability

Temporary Plugging Agents Improve Results From Fracturing Treatment

J. R. PAUL and P. D. MUIR

FOR more than 20 years artificial well stimulation treatments have been applied to oil and gas producing wells, to increase production. One of the foremost problems, both in acidizing and fracturing, is obtaining maximum distribution of the applied materials. It has been determined by use of the spinner and other injection flow meters, that during acidizing operations, a relatively small portion of the exposed formation normally is affected.

Several methods have been devised to obtain better permeability distribution during acidizing, with corresponding production increases. High injection rates have been tried, but with little success. One well was treated with an injection rate of 44 bbl per minute, however, a simultaneous input survey revealed almost three-fourths of the fluid entered one-fourth of the exposed formation (a single zone). One zone received no fluid at all. Two other zones received small percentages.

A more successful method of controlling application of well stimulation materials and obtaining better permeability distribution has been through the use of selective acidizing techniques, utilizing electric pilot subsurface tools and packers.

With development of fracturing treatments for sandstones and acid insoluble formations this problem became intensified. Hydraulic fracturing processes have enjoyed widespread popularity due to the successful application thereof, and some of the phenomenal production increases that have been attained. Many failures have occurred, however, which may be attributed directly to the fracturing fluid entering the formation at the wrong place. Likewise, small productive increases have resulted in some cases, where larger increases were expected. This is probably due to the fact that beneficial effects of the treating fluids were confined to a limited area.

This problem has been solved by development of a new temporary plugging material, that has been in field use for some time. This material has been highly successful in increasing per-

EXCLUSIVE

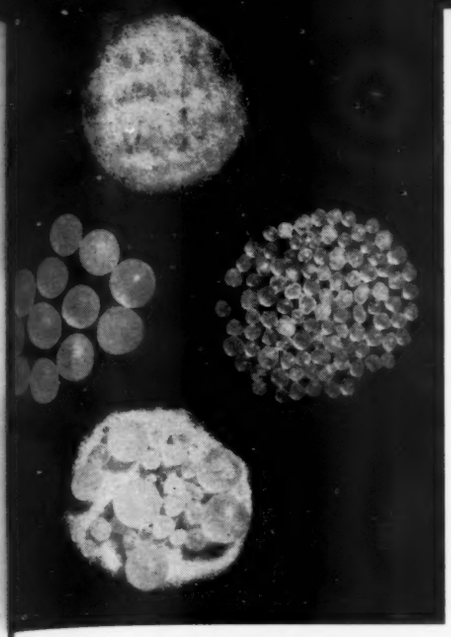


FIG. 2. Individual solid components of the Fixafrac temporary plugging material, consisting of small, large and medium size particles. The combined solids are shown at the bottom.

meability distribution during formation fracturing treatments. This technique is designed to temporarily block initial fractures, thereby allowing a build-up of sufficient resistance to flow to create subsequent fractures. Following completion of the treatment, material dissolves and is returned during clean-up operations, allowing maximum residual permeability distribution.

Plugging Agent

The Fixafrac treatment is conducted utilizing standardized fracturing methods and materials, plus the temporary plugging agent, known as Jel X 830. This temporary plugging material consists of a slightly thickened kerosine-base fluid carrier, containing graded solid particles that filter out as the mixture enters a fracture. The solids have been carefully screened and the particle size distribution is such as to result in forming as efficient a filter cake as possible. The particles range in size from one-fourth inch in diameter down to a 200 mesh powder. The various components are shown in Fig. 2.

These solid particles consist of several different chemical substances that are mixed into the thickened kerosine. Chemical properties of these substances are such that when intimate contact is established in the filter cake, they react with each other, resulting in their subsequent liquefication. Thus, even though a very impermeable plug is formed by these solids, after a predetermined period of time (controlled by catalyst) the filter cake will destroy itself, leaving nothing behind to interfere with production from the previously plugged zone.

The thickened kerosine serves merely as a carrying medium for the solids. The solid particles do the actual work of temporarily plugging the formation. Following treatment, the thickened kerosine mixes readily with the crude oil and is returned to the well bore.

Application

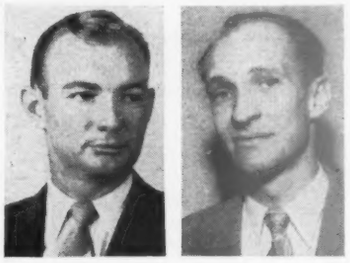
The solids are mixed homogeneously into the thickened kerosine in portable paddle-mixing tanks. Mixing tanks are located on service trucks and connected directly to high pressure pumps that introduce the material into the wellhead. A typical field scene is illustrated in Fig. 1.

Sometimes the temporary blocking material is pumped down the well at the beginning of the treatment. This may be done on refracturing jobs, or in wells where previous fracturing operations have been unsuccessful. In other applications, the material is introduced in intermittent "slugs," along with the regular fracturing medium. Purpose of this procedure is to obtain several fractures in one operation, using a minimum amount of material.

In applying the Fixafrac material, after pumping the mixture into the tubing, displacement is begun with flush oil. Shortly after the calculated volume signifies the material to have arrived at the formation, surface pressures begin increasing rapidly. It is sometimes desirable to completely displace the blocking material before starting the fracturing material down the well. The pressure recording chart, reproduced in Fig. 3, shows the numerous pressure breaks encountered during a typical Fixafrac treatment.

Amounts of temporary plugging material required will vary with the

The Authors



J. R. Paul P. D. Muir

J. R. Paul is district engineer for Dowell Incorporated. He was graduated from Missouri School of Mines with a BS degree in petroleum engineering in 1943. He joined Dowell in 1946 as a service engineer. In 1950 he was promoted to development engineer in the Tulsa office. Since 1952 he has served as district engineer at Wichita, Kansas, where he has assisted in the development and field testing of improved fracturing techniques, including the use of plugging materials.

P. D. Muir is development engineer for Dowell. He was graduated from the University of Arkansas in 1942 with a BS degree in chemistry. He joined Dowell in 1946. As a Dowell research chemist for six years, he assisted in the development of temporary plugging materials.

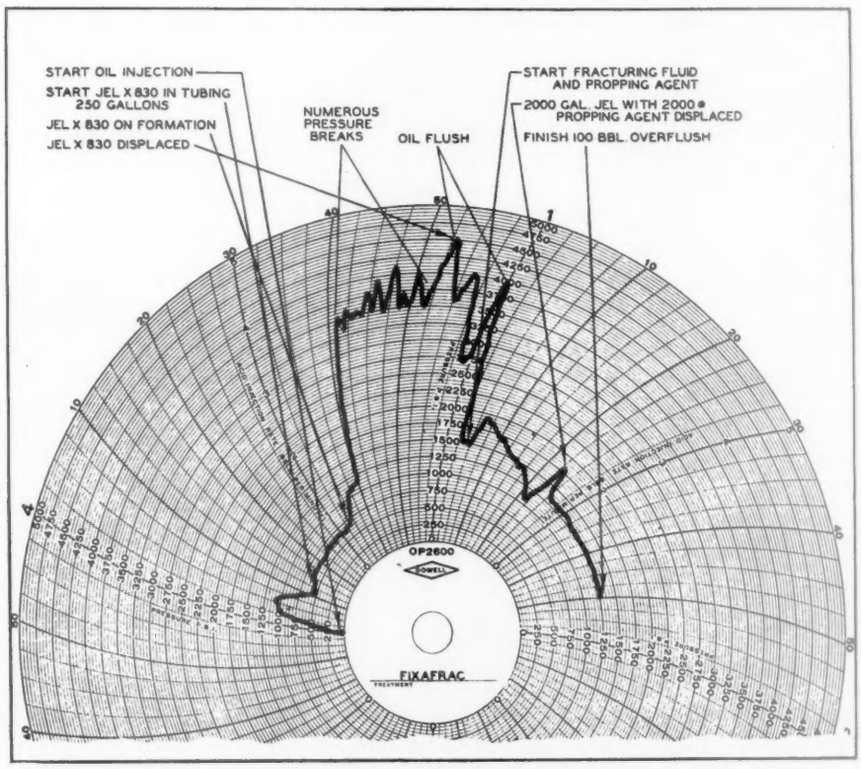


FIG. 3. The above pressure chart illustrates the pressure changes taking place during a typical Fixafrac treatment. The increased injection pressures make possible the creation of new fractures.

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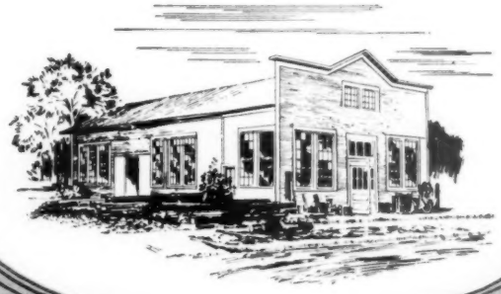

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TABLE 1. Fixafrac results.

Well	Fracturing Materials Used: Propping agent (Pounds)	Fracturing Materials Used: Jel X 830 (Gallons)	Production: Before	Production: After	Remarks
A	2,000	250	0	312 BOD (flowing)	New well; previously fractured w/2250 gal
B	2,000	300	4 BOD	70 BOD	Previously fractured
C	1,500	300	1009 BOD	2330 BOD	Previously fractured
D	2,250	300	24 BOD	324 BOD	Previously fractured with 1500 gal; increased from 15 BOD
E	1,200	300	10 BOD	312 BOD	Previously treated w/500 gal acid; then deepened 2 ft mostly shale
F	3,000	400	12 BOD	50 BOD	Previously fractured
G	6,000	300	24 BOD	840 BOD	New well
H	3,000	300	½ BOD	192 BOD	New well
I	1,200	300	2 BOD	233 BOD	New well
J	2,000	300	4 BOD Show Water	40 BOD 3 BWD	Old well; previously fractured
K	4,000	300	Show	96 BOD	
L	10,000	336	20 BFD (27% water)	168 BFD (27% water)	
M	750	300	25 BOD	84 BOD	
N	3,500	300	72 BOD	1151 BOD (Trace Water)	
O	2,400	300	10 BOD	52 BOD 3 BWD	Previously fractured with 1500 gal
P	6,000	300	10 BOD	288 BOD	
Q	10,000	336	48 BOD	432 BOD	
R	1,200	300	22 BOD	120 BOD	Old well
S	7,000	300	7 BFD (17% water)	130 BFD (16% water)	
T	7,000	336	1 BOD	100 BOD 93 BWD	
U	3,000	300	Show	143 BFD (41% water)	
V	2,250	210	½ BOD 1 BWD	264 BOD 72 BWD	
W	6,000	300	13 BOD 3 BWD	156 BOD (Trace Water)	
X	1,000	200	Show	90 BOD (Trace Water)	
Y	4,000	500	24 BOD	144 BOD	Previously fractured and increased from 1 BOD to 24 BOD

individual well problem. A general formula may be stated as 10 gal for each square foot of exposed formation area to be blocked. By use of permeability and caliper surveys the general area to be plugged usually can be defined. Previous acidization should be taken into consideration. Of necessity there will be some material dissipated on the tubing wall; the depth will be a factor. The amounts shown in the accompanying tables of case histories give a good indication of the quantities required for a successful treatment.

Results

The Fixafrac method has been applied successfully in a number of Kansas wells. Results of these treatments are shown in Table I. There are a number of wells on this list whose ultimate production can be wholly attributed to the use of these temporary plugging materials. For example, Well A had been treated using standard fracturing methods with no increase in production. The Fixafrac type treatment was then used, resulting in 13 bbl of oil per hour, flowing. This production was after all treating fluids had been returned and following the characteristic initial flush production. In fact, all but a few of the results

TABLE 2. Pressure changes using Fixafrac.

Well	Pay Thickness (Feet)	Open Hole or Perforations	Depth (Feet)	Pressure & Rate (PSIG & BPM): Before	Pressure & Rate (PSIG & BPM): W/Filler	Amount of JEL X 830 (Gallons)
1	53	OH	2975	Vac @ 3	1300 @ 2	300
2	68	OH	2268	Vac @ 2	3500 @ Negli.	550
3	26	OH	3332	1000 @ 3	4400 @ Negli.	250
4	14	OH	3274	1700 @ 5	2100 @ 1	300
5	28	Perfs	3337	300 @ 2	6200 @ Negli.	300
6	20	Perfs	3370	800 @ 2	3500 @ 0.5	300
7	11	OH	3408	600 @ 2½	2700 @ Negli.	300
8	10	OH	3040	1000 @ 2	2800 @ ½	300
9	11	Slot Liner	3081	400 @ 4	4200 @ Negli.	300
10	12	OH	3409	500 @ 3	2100 @ Negli.	300
11	48	OH	3358	400 @ 2	2500 @ Negli.	300
12	26	OH	3095	300 @ 2	1700 @ 2	300
13	14	OH	2957	400 @ 2	2900 @ Negli.	300
14	59	OH	4429	950 @ 5	1900 @ 5	500
15	21	OH	3369	600 @ 2½ 1300 @ 5	3800 @ 0.3	300
16	17	OH	2470	1800 @ 1	8000 @ Negli.	400
17	33	OH	4301	900 @ 3	2500 @ 2	300
18	30	Perfs	4310	950 @ 2	4000 @ Negli.	300
19	16	Perfs	4423	1800 @ 1	2600 @ Negli.	300
20	57	OH	3333	Vac @ 3	2400 @ Negli.	300
21	10	Perfs	2303	250 @ 2	3200 @ 2	250
22	24	Perfs	2282	600 @ 2.5	3600 @ 2	300
23	6	OH	2392	1200 @ 1	2100 @ 1	300
24	40	Perfs	2270	1200 @ 1	3100 @ 1	300
25	16	Perfs	2228	1100 @ 1	4300 @ 1	300
26	7	Perfs	2200	1200 @ 1	2600 @ 1	200
27	6	OH	2313	1500 @ 1	3600 @ 1	400
28	7	OH	2418	1300 @ 6	2000 @ Negli.	210
29	3½	Perfs	2389	1400 @ 5	3900 @ Negli.	300
30	5	OH	2410	1400 @ 7	2400 @ Negli.	300
31	9	OH	2351	1200 @ 4	2400 @ 2	336
32	5	Perfs	2215	1200 @ 4.6	5000 @ Negli.	300
33	6	OH	2347½	1300 @ 5	2100 @ Negli.	336
34	4	Perfs	2388	1300 @ 5	3200 @ Negli.	420
35	11	Perfs	2392	1200 @ 5	2100 @ Negli.	336
36	6	Perfs	2329	1200 @ 5	2200 @ Negli.	300
37	6	Perfs	2333	1600 @ 5	3200 @ Negli.	336
38	15	OH	2510	200 @ 4	2300 @ 1	350
39	24	OH	3542	1700 @ 5	4400 @ 3	300
40	11	OH	4354	2500 @ 5	4600 @ Negli.	300
41	18	OH	3799	2400 @ 1	5400 @ Negli.	300
42	12	Perfs	3618	1800 @ 2	5000 @ Negli.	300
43	20	OH	3300	Vac @ 3	1500 @ Negli.	500
44	26	OH	3507	1400 @ 1½	5300 @ Negli.	300
45	6 3	OH Perfs	3613	1300 @ 4	3800 @ Negli.	300
46	26	OH	1507	200 @ 2 600 900	600 @ 1 900 3500	100 200 600
47	25	Perfs	4205	1900 @ 1	4000 @ 1	300
48	10	Perfs	4369	1300 @ 2	4500 @ 1	300
49	2	OH	3282	2600 @ 2	4600 @ Negli.	200
50	9	Perfs	3086	Vac @ 2	1000 @ 2	300
51	6	Perfs	3032	1300 @ 2	3300 @ Negli.	300

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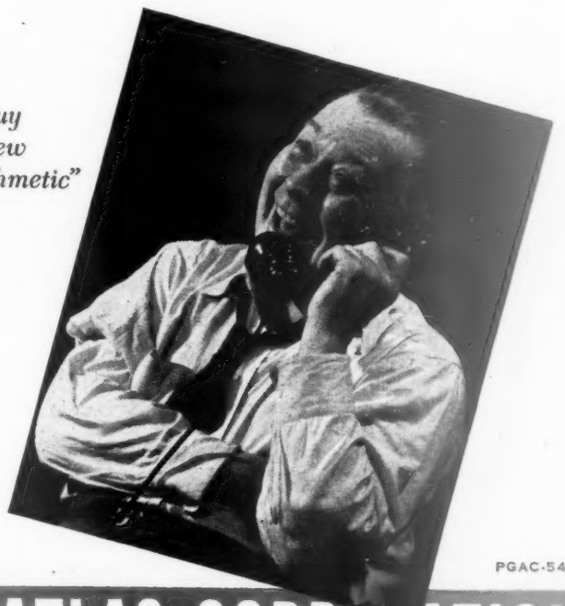

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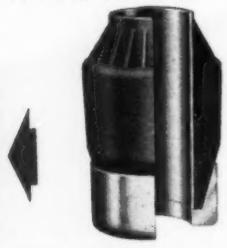

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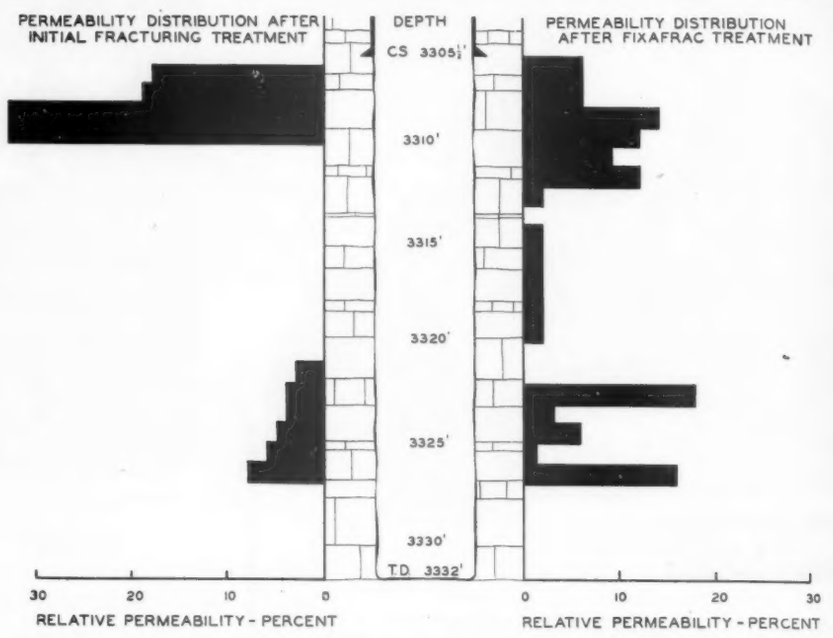


FIG. 4. The use of temporary plugging materials improves the results of fracturing treatments by providing improved permeability distribution over the face of the pay, rather than confined to one or two fractures.

listed in Table 1 were stabilized when obtainable; the rest are considered to be highly indicative.

The reason for improved results obtained by this type treatment has been fairly well established by means of injection surveys, made before and after Fixafrac treatments. For example, in Well A described above, Spinner surveys were conducted in order to determine the relative permeability over the open-hole section, and any changes effected by the treatment. These comparative permeability profiles are shown in Fig. 4.

It may be seen that following the first fracturing treatment (which failed) the major portion of the injected fluid entered the formation in the first four feet below the casing shoe; 33 per cent from depths 3308 to 3310 ft. This was correlated to a questionable shale zone. Following the Fixafrac treatment, additional zones totalling eight and one-half feet were opened; this means that the permeability distribution was increased 85 per cent over the initial profile.

Table 2 shows a list of injection pressure increases obtained by the use of Jel X 830 on a number of wells. Corresponding pay thicknesses, completion methods and depths, with amounts of material used, are shown. The injection rates in barrels per minute were recorded simultaneously with the injection pressures, in pounds per square inch. The greatest change observed was 6200 psi (Well 16). Many wells could not be filled before the introduction of Jel X 830. Therefore, the total pressure change cannot be determined. In many cases the injection rate of the plugging material was purposely retarded or temporarily stopped for fear of exceeding pressure limitation of the well equipment.

Conclusions

The Fixafrac type treatment using Jel X 830 material may be successfully used to create additional fractures that result in maximum permeability distribution, ultimately establishing higher petroleum production. It may be used not only with the different types of fracturing processes but also with acidizing treatments.

Fixafrac has been a highly beneficial development for the oil production industry. It will continue to contribute added oil production, some of which would not be obtainable otherwise. ★

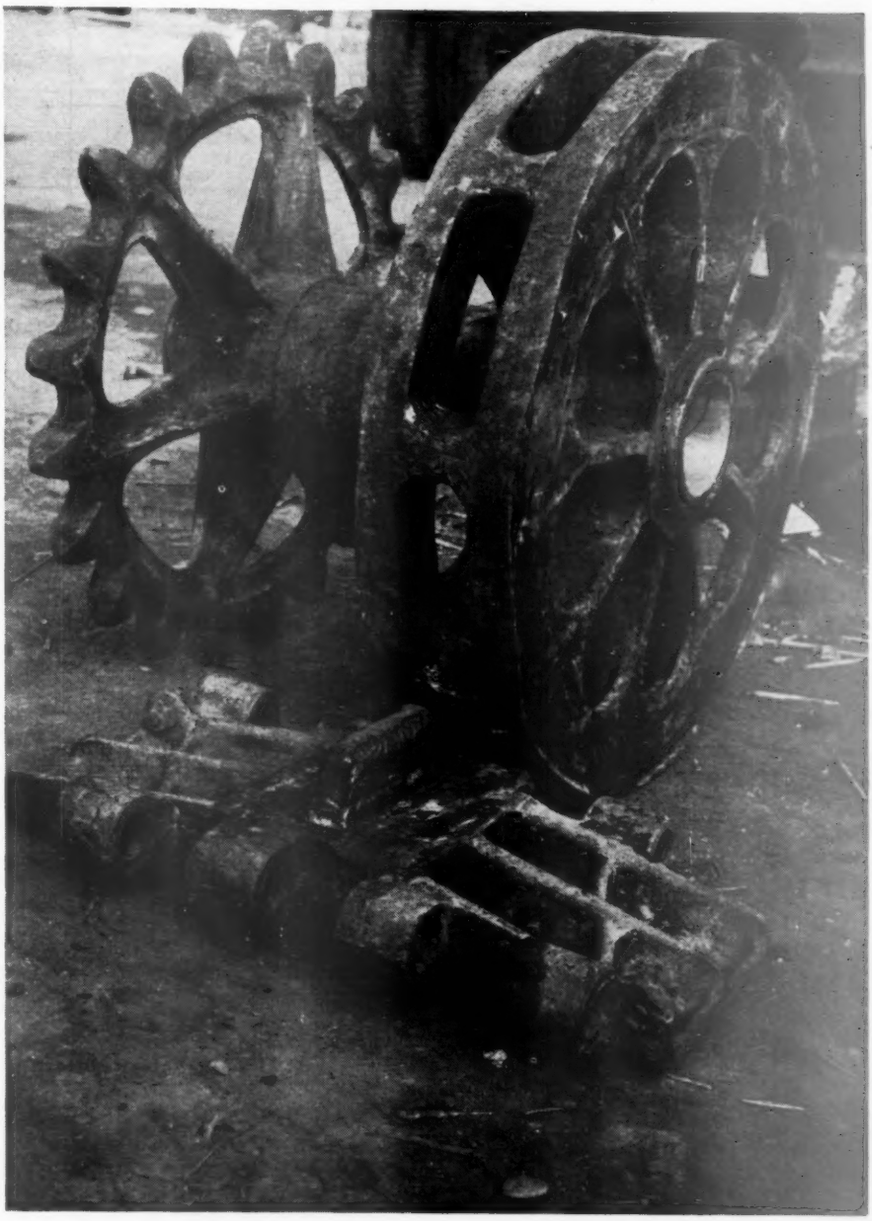
Natural Gas Use Rises

Many people in the oil business still tend to think of natural gas as a promising but small sideline of the petroleum industry. But economists for the big oil companies paint a different picture. They point out that natural gas production, on a Btu basis, already has reached a level roughly half of that of the entire petroleum industry itself. And, it is growing at a faster rate. Last year natural gas production rose 7.5 per cent, petroleum 2.3 per cent. This year the gains are expected to be 10 per cent and 1.5 per cent respectively.

How to keep crawler parts operating longer

Replacing worn shovel parts is costly ...for example, the sprocket, tumbler and track assembly illustrated, which represents a considerable outlay.

The experience of a large pipeline company operating in the West, provides a good example of maintenance procedures that cut replacement costs and save lost equipment time. Two sets of sprockets, tumblers and tracks are maintained for each backhoe. The spare set is rebuilt and hard-faced on regular shop time. It is ready for instant use when needed. When the track shows signs of slipping, the rebuilt equipment is sent out, worn parts are removed and the spares installed on location.

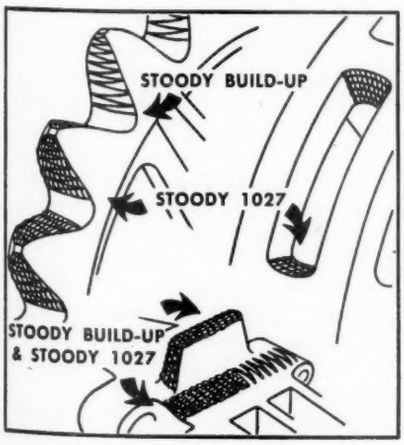


NUMEROUS ADVANTAGES

Work schedules in the welding department are thus smoothed out, since rebuilding and hard-facing jobs can be used as "time fillers" at the welder's convenience without overtime costs.

Shovel down-time is reduced. Only enough time is lost to pull worn assemblies and substitute the spares. Shovels are immediately put back on the job.

Although no exact record is available, careful observation over a long period of time indicates an almost indefinite increase in service life for these specific parts. The procedure has proved so successful it is now adopted as standard practice.



REBUILDING & HARD-FACING PROCEDURES

Wear patterns are the key to the most effective use of hard-facing. Worn areas of sprocket teeth, lugs and tumblers are rebuilt to within $\frac{3}{16}$" of final size with Stoody BUILD-UP, which provides a rigid base to properly support the hard-facing alloy. A final pass of Stoody 1027 supplies good wear resistance with high impact strength. These same alloys are used on the pads to restore size and renew life.

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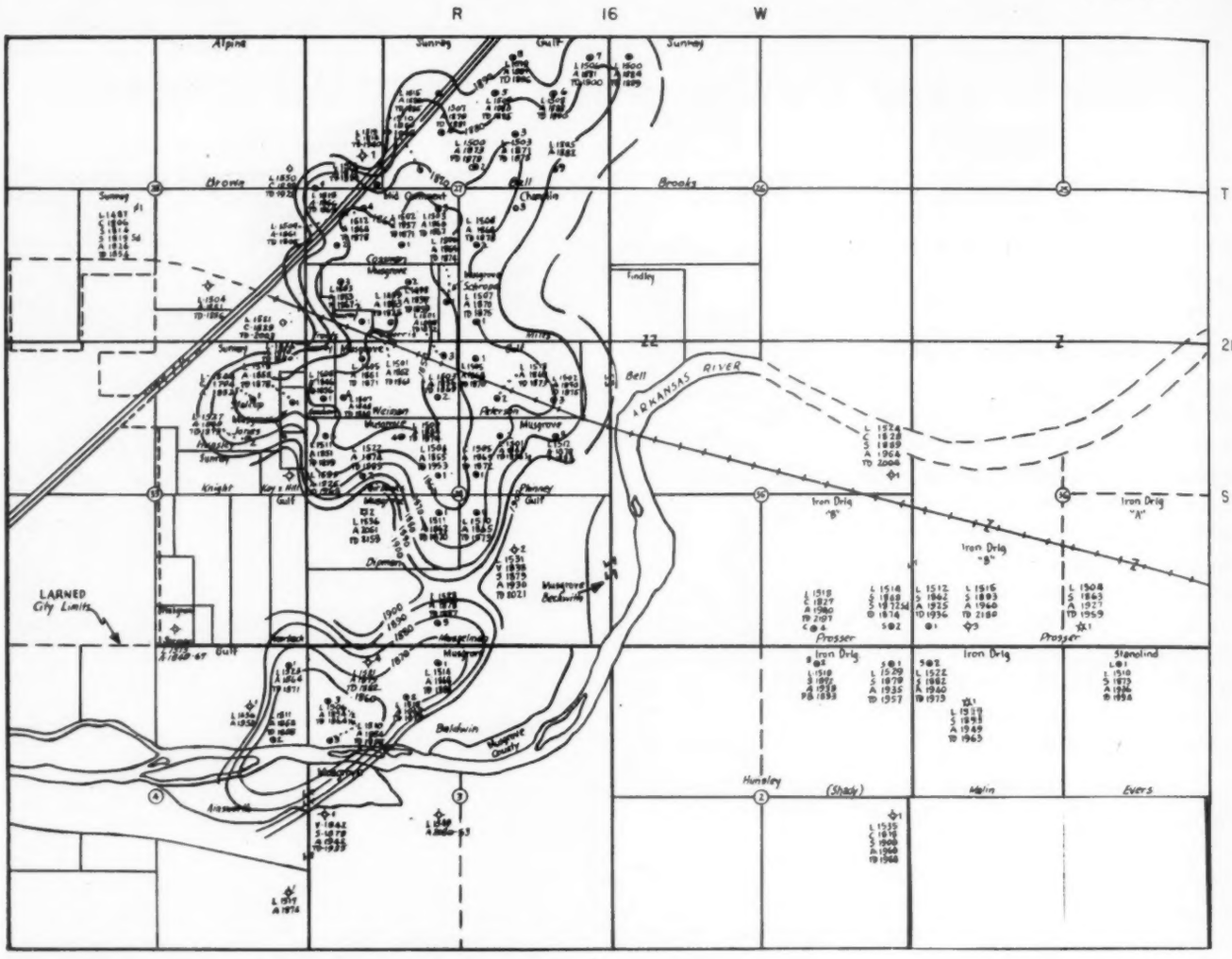

FIG. 1. Map of Larned pool in Pawnee County, Kansas.

Thick Pay, Good Recovery Highlights Larned Pool

Field contains two producing areas: The small Southern one has 6 wells and 41 gravity oil as compared to 48 wells and 36 deg oil in the Northern pool

C. P. CHANDLER, JR.

IN July of 1952, Musgrove Petroleum Corporation recovered 3360 ft of clean oil on an Arbuckle drillstem test from its No. 1 Phinney in Pawnee County, Kansas. The well was subsequently completed for a potential of 3000 bbl per day. This was the discovery well of the Larned pool. Today, some 21 months after the discovery well was drilled, the pool contains 54 producing wells. All of the production is from the Arbuckle Dolomite at a depth of about 3850 ft. One of the most notable features about the pool is the unusual thickness of pay.

The second well drilled in the pool, Musgrove's No. 1 Fairbanks was diamond cored in the Arbuckle. Results of the core analysis are shown in Fig. 2. The oil-water contact was established 52.5 ft below the top of the Arbuckle. Core Laboratories, Inc. reported the following average figures for the oil bearing section; porosity 9.8 per cent, permeability 215 milidarcys. A combination Gamma Ray, Laterolog, Microlog, Schlumberger log was run on this same well. An analysis of the electric log, which is shown in Fig. 3, by Louis Chombart of Amstutz and Yates, Inc. revealed, average weighed porosity 11.4 per cent through the oil bearing section and an oil-water contact 51 ft below the top of the Arbuckle. Core Lab's calculations, assuming an active water drive, shows that this well should recover 272 bbl per acre-foot.

EXCLUSIVE

The pool essentially has been drilled on 20-acre spacing, although the drilling pattern is irregular due to the irregular and small size tracts adjacent to the town of Larned.

Using the electric log analysis to de-

CORE LABORATORIES, INC. CORE LAB *Petroleum Reservoir Engineering*

COMPANY	MUSGROVE PETROLEUM CORPORATION	DATE ON	10/7/52	FILE NO.	CCL-1053 S
WELL	FAIRBANKS NO. 1	DATE OFF	10/16/52	ENGRS.	PUGH
FIELD	UNKNOWN	FORMATION	ARBUCKLE	ELEV.	1985' DF
COUNTY -	PAWNEE STATE KANSAS	DRLG. FLD.	WATER BASE MUD	CORES	DIAMOND
LOCATION	SE-SE-NW SEC. 34-21S-16W	REMARKS	SERVICE NO. 9		

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PERMEABILITY, Maximum O–O MILLIDARCYS 80 60 40 20 0 — TOTAL WATER O–O PERCENT PORE SPACE 80 60 40 20 0 — POROSITY x----x PERCENT 40 30 20 10 0 — OIL SATURATION x----x PERCENT PORE SPACE 0 20 40 60 80

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS MAX	90°	POROSITY %	RESIDUAL SATURATION % PORE SPACE OIL	TOTAL WATER
1	3841.0-42.0	13	10	13.6	4.2	85.2
2	3842.0-43.0	23	0.9	5.8	27.7	65.2
3	3843.0-44.0	71	44	9.7	24.6	44.6
4	3848.0-49.0	*	*	8.2	7.6	80.1
5	3849.0-50.5	68	49	10.2	17.8	51.3
6	3850.5-51.5	*	*	11.2	14.9	56.5
7	3851.5-53.0	378	251	9.9	23.0	46.8
8	3853.0-54.2	755	378	8.1	22.7	44.7
9	3854.2-55.2	107	41	11.4	13.7	54.7
10	3856.0-57.5	50	1.7	10.5	12.9	70.7
11	3857.5-59.0	198	148	12.7	16.9	59.2
12	3859.0-60.4	48	26	11.4	26.2	46.7
13	3860.4-61.5	1940	1530	12.4	23.5	46.5
14	3861.5-63.0	*	*	5.2	14.2	72.7
15	3863.0-64.7	261	175	9.0	13.9	66.3
16	3864.7-66.5	12	11	11.0	15.1	64.0
17	3866.5-67.9	2.6	2.6	8.7	3.3	83.0
18	3867.9-69.5	489	88	7.9	17.2	58.2
19	3869.5-71.0	7.9	3.9	5.5	18.8	56.7
20	3871.0-72.1	3.2	1.2	4.8	19.4	62.8
21	3872.1-73.7	335	335	6.8	15.6	55.1
22	3873.7-75.0	5.4	3.6	7.2	19.6	49.0
23	3875.0-76.3	566	102	13.7	21.7	47.1
24	3876.3-77.3	210	18	7.1	18.6	61.2
25	3877.3-79.0	77	57	10.3	11.5	73.2
26	3879.0-80.5	6.4	5.2	7.6	18.4	55.0
27	3880.5-82.0	74	68	12.2	21.6	51.2
28	3882.0-83.5	12	11	17.6	14.5	61.0
29	3883.5-84.8	28	12	14.0	15.8	67.4
30	3884.8-86.0	74	40	10.8	13.2	70.3
31	3886.0-87.5	8.9	6.1	7.9	7.0	71.5
32	3887.5-89.0	57	3.8	8.3	9.2	68.2
33	3889.0-90.4	95	91	12.0	12.3	61.9
34	3890.4-91.8	5.8	5.1	9.4	17.2	56.5
35	3891.8-93.3	106	61	9.8	24.8	46.2
36	3893.3-94.5	22	19	6.3	10.7	59.3
37	3894.5-95.9	7.6	2.3	5.6	3.8	84.0
38	3895.9-97.2	16	11	19.1	1.1	91.5
39	3897.2-98.5	101	69	22.9	1.0	94.3

D.S.T. 3841-48' Rec. 480' oil and 150' Muddy Oil B.H.P. 1240#

D.S.T. 3848-63' Rec. 3411' Oil F.H.P. 1220#

FIG. 2. Core analysis data of Musgrove Petroleum's No. 1 Fairbanks in Larned pool.

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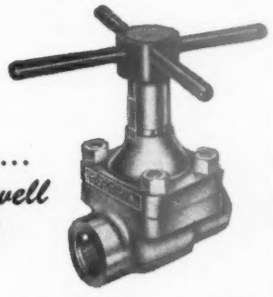

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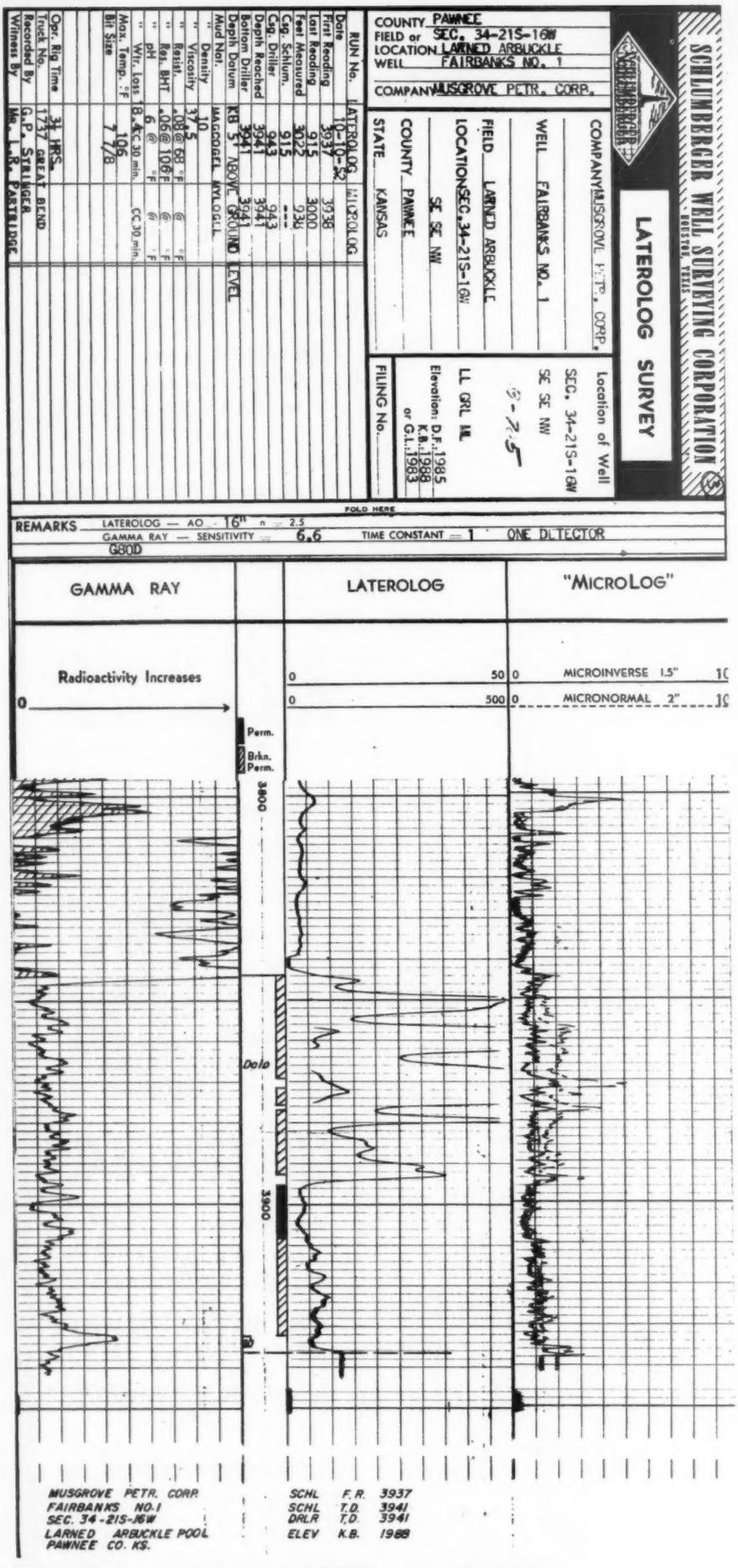

FIG. 3. Electric log of Musgrove Petroleum's No. 1 Fairbanks.

The Author

C. P. Chandler, Jr. is vice president of Musgrove Petroleum Corporation. Graduated from Purdue University in 1948 with a degree in mechanical engineering, he spent 4 years with Sohio Petroleum Company in Shreveport, Louisiana, and Wichita, Kansas. He has been employed by Musgrove Petroleum Corporation since October of 1952. Musgrove is one of the larger independent oil producers which operates 2000 bbl per day of production and 3 rotaries. The company's operations are confined practically altogether to the state of Kansas and drills about 40 deals per year.

termine the oil bearing section of 51 ft, and using 20 acre spacing and 272 bbl per acre-ft of recoverable oil, this well should recover approximately 277,000 bbl of oil which is far above the average per well recovery encountered in Central Kansas.

Regionally, the Larned pool lies on the southwest flank of the Rush Rib of the Central Kansas uplift. Actually two producing features are included under the nomenclature "Larned pool." The southern one is the smaller and contains at this time 6 producing wells. It produces 41 gravity oil as compared to 36 gravity oil in the main feature to the north. Because of the early production of water in this section, it is assumed that a thinner oil bearing section exists here than in the north. Main feature to the north, which contains 48 wells, was probably brought about as a result of erosion during or after Mississippian times, which formed an Arbuckle plateau influenced to some degrees by Arbuckle structure. Much of the porosity, which is largely vugular and somewhat intercrystalline may have been the direct result of that erosion.

Another interesting point about the Larned pool is the high degree of success encountered in the development. For example, Musgrove Petroleum drilled 23 tests, which resulted in 21 oil wells and 2 dry holes. Of the 21 producing wells, 16 were completed for maximum 3000 bbl oil per day wells.

The Larned pool is notable because of its thick oil section and because of the good quality of other reservoir conditions. It is one of the outstanding pools discovered in Western Central Kansas in the past several years. * *

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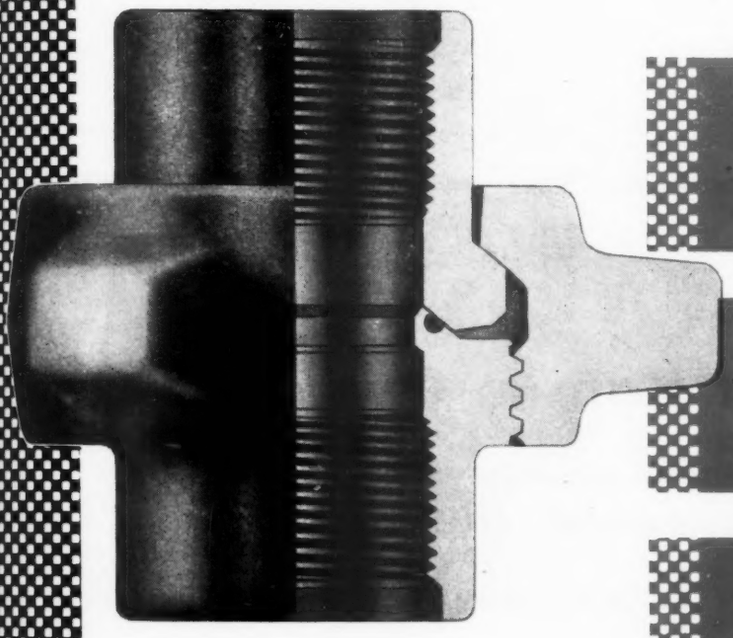

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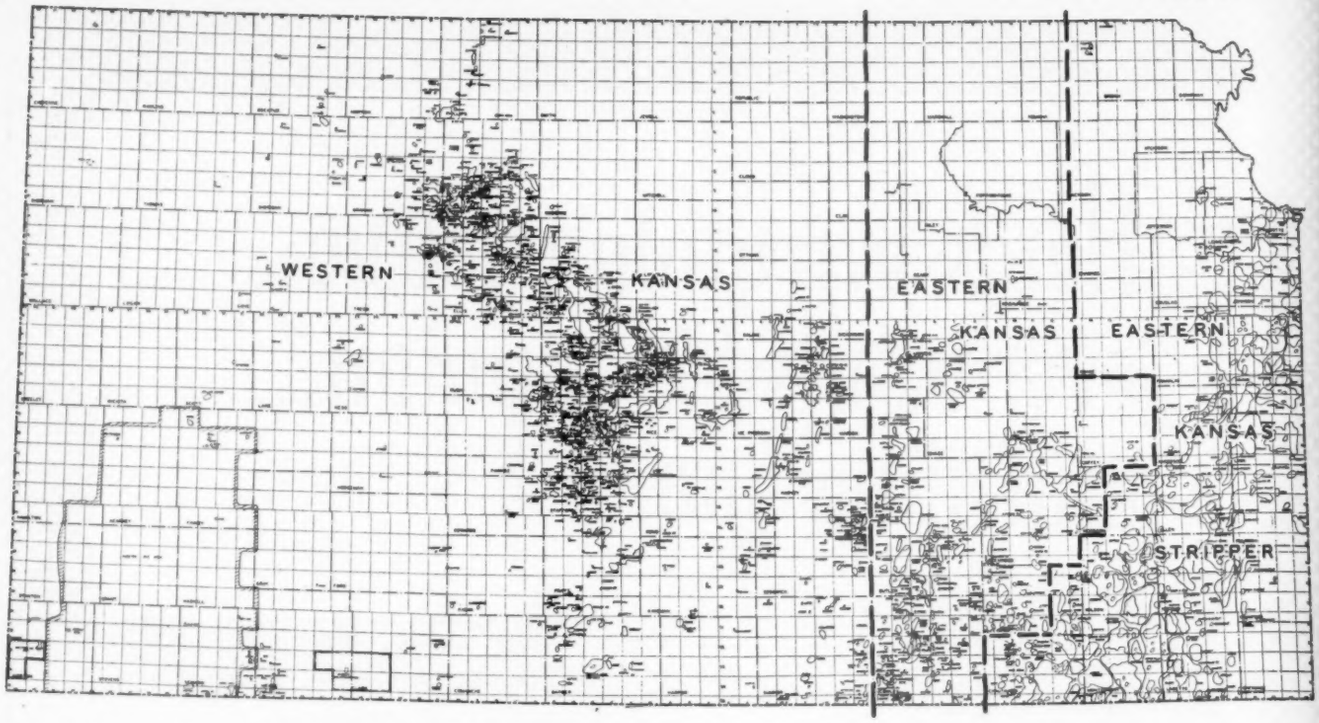

FIG. 1. Kansas Corporation Commission divided state into three areas, Western Kansas, Eastern Kansas, and Eastern Kansas Stripper, for administration of conservation laws.

Economics of East Kansas Operations

Costs must be kept at minimum to operate profitably in stripper area and more subsurface data are needed for efficient development

F. W. MORGAN and M. E. TORLINE

KANSAS Corporation Commission, oil and gas division, has divided the state into three areas (Fig. 1) for the purpose of administering the state conservation laws. This article concerns itself with the two areas designated **Eastern Kansas** and **Eastern Kansas Stripper.** For practical purposes they will be referred to here together as **East Kansas,** unless otherwise specified.

The first wells in Kansas were three drilled in Miami County in 1860. Oil was found in one of these. By 1904 Kansas oil production had reached an annual figure of more than 4,000,000 bbl. In those days, however, gas was more valuable and more marketable than oil, so the emphasis was on finding gas, and many oil shows were passed by and the wells were completed as gas wells. Since 1860 there have been alternating cycles of boom and lull, and, with the advent of fracturing processes, the boom is on again.

In the stripper area last year the daily average production was about 2 bbl a day from wells varying in depth from 400 to 1200 ft. This average includes all wells in the area—some 50 years old, some new, and some in the secondary recovery projects. There is no way of getting averages on fractured wells, but the prevalent opinion is that it does increase productivity in the Pennsylvanian sands.

In 1953 in Eastern Kansas the daily average production was approximately 7 bbl a well. The depths of these wells vary from 1200 to 3500 ft. Here again fracturing the sands has given great impetus to productivity, but there is a great deal of oil being found in the older formations too.

By way of comparison, last year Western Kansas had a daily average production of 16.42 bbl a well. These wells average from 2100 to 6100 ft deep. Most of them are in the 3200 to 3800 ft range. Last year there were 4450 wells drilled in Western Kansas and approximately 4212 drilled in East Kansas including oil, gas, and input wells. The table below gives average daily production (total) from the three areas.

	January 1953	January 1954
Eastern Kansas Stripper (includes secondary recovery)	13,549 bbl	14,057 bbl
Eastern Kansas (includes secondary recovery)	56,443 bbl	55,469 bbl
Western Kansas (prorated)	267,236 bbl	235,712 bbl

EXCLUSIVE

Methods of Exploration

The most common method of looking for oil in East Kansas is by using the old cable tool drillers' logs. The Kansas Well Log Bureau has a good collection, and 40 to 50 per cent of them are accurate in listing locations, shows of oil, sand thicknesses, and water zones. They are also useful in locating the Mississippian gas fields, which undoubtedly produce on structure and which may have, on and flank-

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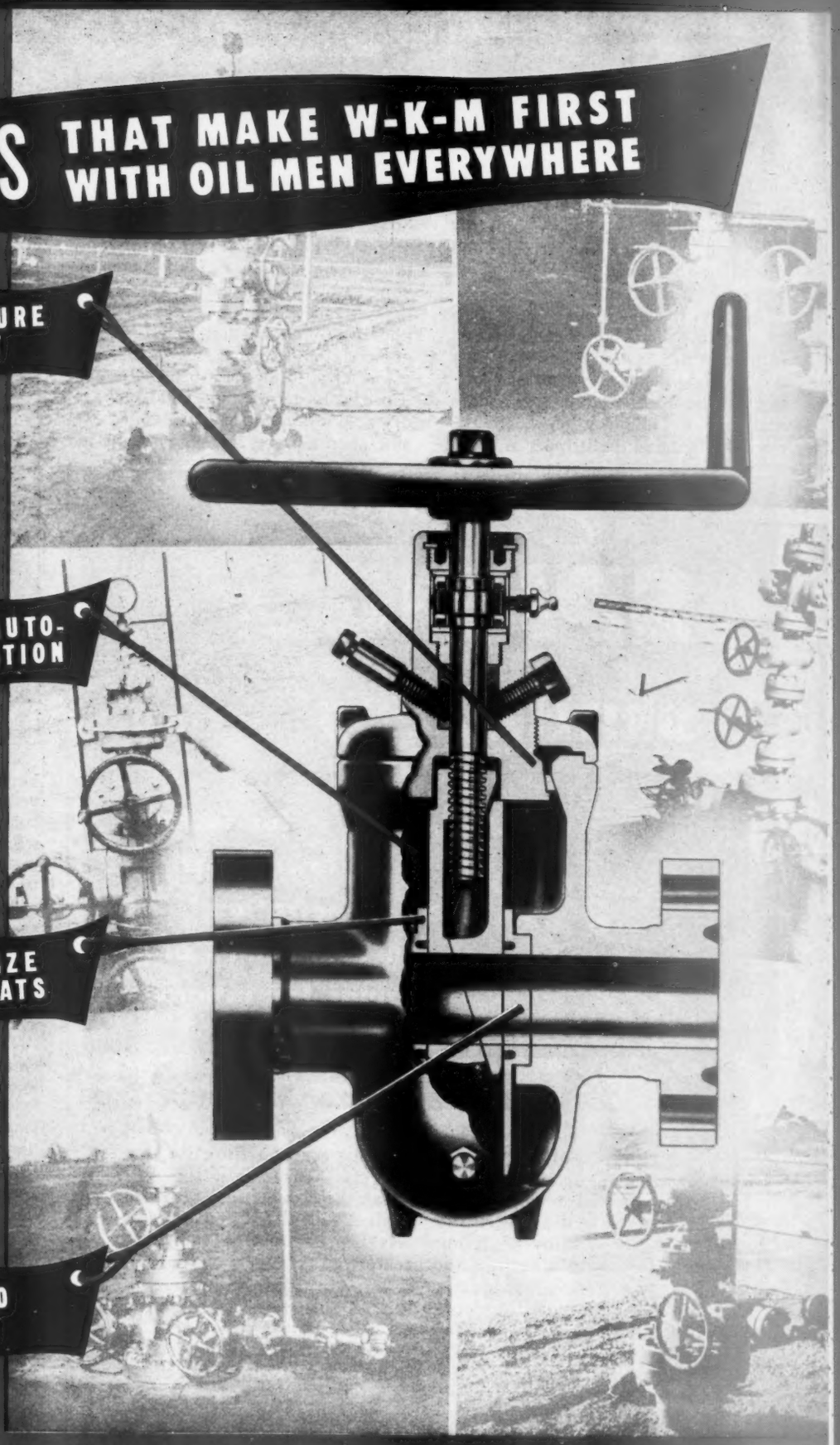

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ing them, oil sands that have not been produced. When 15 or 20 ft of sand has been found and confirmed by appearing on several logs, the evidence is considered conclusive enough to warrant drilling a well. Supplementary information can usually be got by visiting the area and observing the ground and questioning the local people about old wells drilled nearby.

There is an elevation service in parts of Eastern Kansas but none in the rest of it or in the Eastern Kansas stripper area so that little or no subsurface geology can be done. Rather, trend plays and sand development plays are the rule. Operators in the stripper area are not careful about protecting offsets as they are in other parts of the state, and leases may be had close to producing wells. Getting accurate information on these wells is sometimes quite difficult. In the past much surface work has been done, and we have heard rumors of recent seismic exploration being done in Eastern Kansas, but we know of none east of Butler and Cowley counties. Magnetic surveys are reported underway in Chatauqua and Montgomery counties. Since the large scale use of electric logs has become established in Eastern Kansas, the study of dry hole logs together with sample examination has resulted occasionally in an offset being drilled or the old hole being washed down for a successful completion. This is especially effective where the original well was drilled prior to the development of fracturing. We have no data at present on number of jobs or percentages of success.

Geology. In reviewing the geology of East Kansas we are emphasizing the stripper area, for it is there that the techniques of fracturing formations and water-flooding have brought about such a great revival of interest and activity. We realize that this area is the least understood of any in Kansas, at least in the oil industry, and that the lack of a scouting service together with the profusion of local terminology will result in many differences of opinion among operators, some of whom will not agree with us. Nevertheless, we shall attempt to present the area as it appears to us.

Outcropping rocks range from Upper Permian in the west to Mississippian in the extreme southeast corner of the state, the regional dip being to the west. Structural features (see Fig. 2) are the Nemaha Granite Ridge on the west, the Forest City Basin in the northeast, and the Chatauqua Arch to the southeast. Oil and gas are found in and on all these structural provinces.

Subsurface rocks producing oil and gas in the areas here described are as follows in geologic column. We have reproduced the rock column only from the youngest to the oldest reservoirs, and this holds true for the whole area with very few exceptions:

The Authors

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Cherokee Group

MISSISSIPPIAN SYSTEM
SILURO-DEVONIAN SYSTEM
ORDOVICIAN SYSTEM

In East Kansas the Arbuckle, Simpson, and Viola rocks of Ordovician Age have produced and are producing tremendous quantities of oil and gas. In the northern half of our area, especially west of the Nemaha Ridge, Siluro-Devonian rocks are prolific pays. And the Mississippian rocks, both the Chat and the Lime, are good producers of oil. It is realized by the writers that the above rocks as reservoirs have been adequately covered in the literature and that here we need only list them. These reservoirs, with few exceptions, produce on well-defined structures that can be mapped on subsurface and sometimes on the surface. The reservoirs being discovered today in Pennsylvanian rocks are not structural at all but are mainly stratigraphic traps along the flanks of the older structures, and they owe their accumulation to facies changes or pinching out over the tops of the structures. The sands are usually fine, micaceous, shaly, and somewhat laminated. They would not produce oil and gas in commercial quantities in many cases without treatment of some kind.

The Desmoinesian series in Kansas rests unconformably on the rocks below and is separated from the Missourian above by a disconformity. Probably only the middle and upper parts of the Cherokee group are present in most of Kansas east of the Nemaha Ridge, but they may develop as many as three sands which are likely to produce oil. The lowest, commonly called "Bartlesville," is thought to be the Red Fork of Oklahoma. It has in the last two years been responsible for a big play in Cowley County where a great many wells have been completed in it. In addition it has produced great quantities of oil over most of the entire area for many years. There may be another sand developed at about the base of the Upper Cherokee. If so it is called "Cattleman" locally and carries oil. The upper sand in Cherokee rocks is the Prue, known locally as the "Squirrel." It is a prolific producer in the stripper area, particularly in the northern part. The number and development of Cherokee sands depends mainly on thickness or thinness of the Cherokee, that is whether it is on structure, flanking, or completely off.

The Marmaton group probably varies as much or more in lithology and thickness as any subdivision of the Pennsylvanian. The disconformity at the top may, on and near older structures, cut into the Marmaton rocks as deeply as the Labette shale, leaving only a part of this shale and the Fort Scott limestone representing the entire group. This situation occurs mainly in Cowley County, where the Pleasanton sand, called Cleveland in the subsurface, lies above the Fort Scott. To the east more and more of the Marmaton rocks appear to be present, a full section being found near the outcrop. Any of the four shales in this group, if present, may develop a sand, and all do at one locality or another. The sand in the Labette is known as the "Peru," the one in the Bandera as the "Weiser," and that in the Nowata as "Wayside" or "Old Red." A sand developing in

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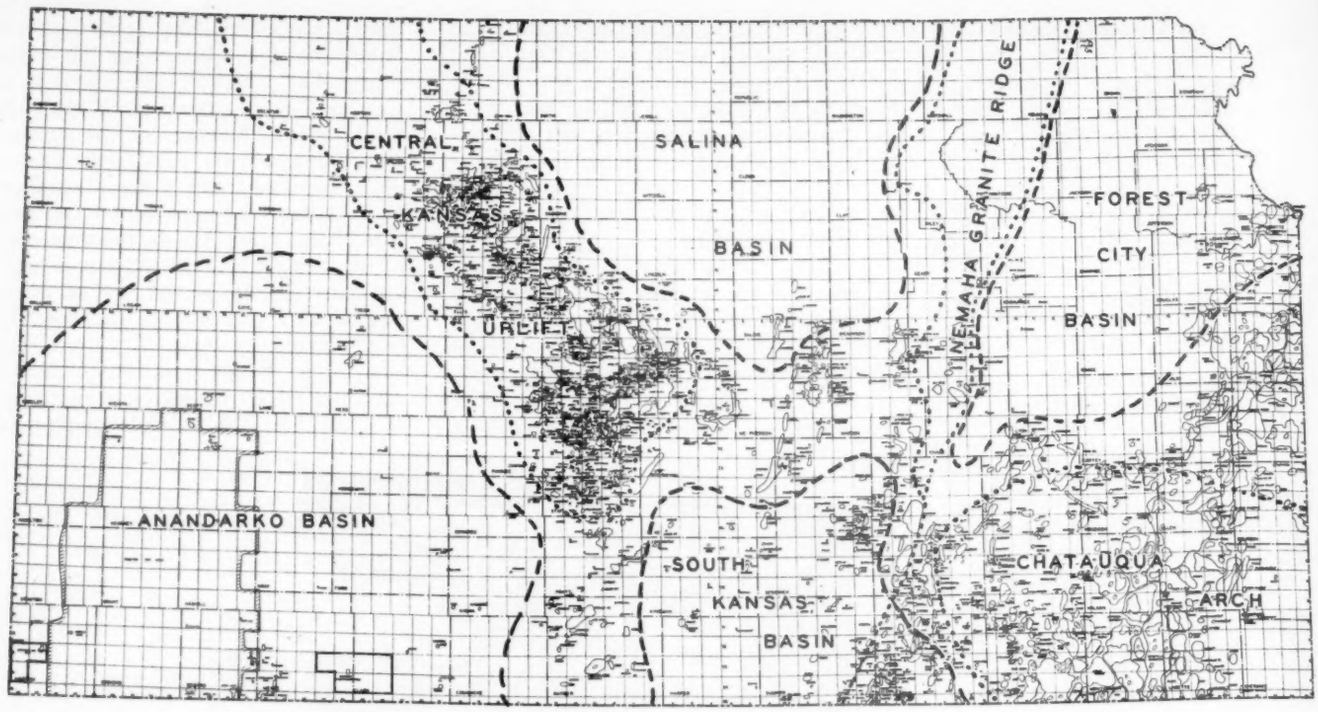

FIG. 2. Location of major structural features identified in Kansas.

the Memorial shale is generally classified as basal Pleasanton and not Marmaton in age.

All these sands produce, mainly in the stripper area, where they are best developed, and are largely responsible for the revival of activity in Elk, Chatauqua, Wilson, Neosho, Labette, and Montgomery counties. The Fort Scott may develop a sand between its two lime members and has produced gas for years from the limes. The "Oswego," as it is still called, is recognizable by its white, dense character and the black shale member. The only other Marmaton limestone readily recognizable in the subsurface is the Pawnee or "Pink," a very descriptive term for this pink, dense, lime.

As stated above the Pleasanton sand is usually called Cleveland in the subsurface. It may lie, if present, just above any member of the Marmaton, depending on how deeply the disconformity cuts. The only other recognizable Pleasanton member is the Checkerboard Limestone, a brown and white, coarsely crystalline lime above the sand. Cleveland production has been obtained in Cowley County just north of the state line and near Kay County, Oklahoma, producers.

The Lansing and Kansas City groups of the Missourian series are predominantly limey over most of the state, but to the south they gradually change into a sand and shale sequence so that at the state line little or no lime is found. Where these rocks are lime, they are producing reservoirs, and where they are composed of sands and shale production is also obtained. In Elk and Chatauqua counties local sands developed at the base of the Kansas City are called "Dodds Creek," the most widely used local name. The main Kansas City sand is the Layton, which produces in Butler, Greenwood, Cowley, and Elk counties. It may develop a thickness of 100 ft as a good, clean sand, and will produce on structure with considerable closure being essential for accumulation. In eastern Cowley County, however, trap type accumulation has been recently developed in this sand. The Pedee-Lansing sand is named "Stalnaker" and produces under approximately the same conditions as the Layton. It, too, may be almost 100 ft thick and differs very little in character from the Layton.

There are a very few instances of younger sands than those listed above being found productive in the western part of Eastern Kansas, but practically all the oil being found today in Eastern Kansas and Eastern Kansas stripper areas is from the reservoirs we have reviewed.

Drilling and Operations. Most stripper area wells are drilled with cable tools which charge about $2 per foot, but a few light, portable rotary rigs have been introduced and have been used successfully. They usually charge about $2.50 per foot. In Eastern Kansas the opposite is true, and most wells are drilled with rotary. Prices are slightly higher since the rigs are heavier and holes deeper.

There are arguments that in the stripper area rotary drilling in low pressure sands tends to mud off these sands, but fracturing should overcome any ill effects. Common practice with rotary is to core the sands and have the core analyzed. Some cable tool cores are taken and analyzed also. Most of the new wells do not have much fill-up before treatment, and, therefore, the advantage of using cable tools to check fill-ups is largely nullified. It is difficult to find a contractor with fewer than three or four wells ahead and who has an immediately available rig.

All over East Kansas wells are completed both by running casing to the top of the sands or by setting casing through the sands and perforating. Electric and radioactive logging are being used more frequently. There is one rather unusual practice in the stripper area that is not used anywhere else. That is using no casing below surface pipe but running tubing with an open hole packer; then siphoning cement down the outside of the tubing and allowing it to set. After fracturing an insert pump is run on the end of a string of one-inch pipe and rigged to pump through the pipe, and flexible hose is run from the pumping unit bridle to the lead line. This method began during the war when casing was hard to get and is dying out, but a lot of wells have been completed in this manner. When casing is used it is with common working barrels and conventional equipment.

Most leases in the stripper area are pumped electrically and use a time clock system. Some pump as few as five or six strokes per minute. Some of

the old leases are still being operated with central power units, and some new leases are being similarly equipped.

We have found that to drill, complete, and equip the first well on a lease at a depth of about 1000 ft is approximately $8000. Most of the oil produced must be hauled to refineries such as those located at Chanute, Coffeyville, Neodosha, or to some receiving point on a pipe line. Hauling cost averages 30 cents a barrel, actual price depending on the distance. In the case of low gravity crudes, some additional charge may be made for treating where the operator does not have adequate treating equipment. In most cases a common gunbarrel separator is adequate to remove water and basic sediment. The problem of trained personnel is more acute in these areas than elsewhere because the shallower, smaller wells do not allow as much overhead in lease operation as do richer areas. For this reason trained pumpers and other personnel cannot be found for the small independent operator who does not have a production staff of his own. Unless he lives near his leases and can do the jobs himself he must use local people who may not have the desired experience.

Leasing. Many of the leases in East Kansas can be bought for a dollar an acre and, in many cases, can be had for a drilling commitment on (or offsetting) the lease. Much of the acreage is leased, but there is still plenty available. Although Eastern Kansas and Eastern Kansas stripper areas are thought of as the Independents' Paradise, many leases are held by major companies. Operators in the stripper area generally neither give nor ask dry hole support on drilling wildcat or extension wells, but the low cost at such shallow depths allows them to drill and operate without it.

There are many promoters busily turning drilling deals here. The usual price is a small cash consideration plus a one-sixteenth override. In the stripper area some are asking one-fourth or more of the working interest carried to the pay. Our observation is that more than one-thirty-second override is uneconomical and that free working-interests are prohibitive. It must be allowed that in Butler and Cowley counties the production is good enough to carry a slightly higher override.

Secondary Recovery. Water flooding has been adequately described in other writings, but it forms such a large part of oil operations in East Kansas that it must be mentioned here. There are approximately 250 floods in operation in the whole area and several gas injection projects. All gas injection we are aware of is owned by major companies, but independents as well as

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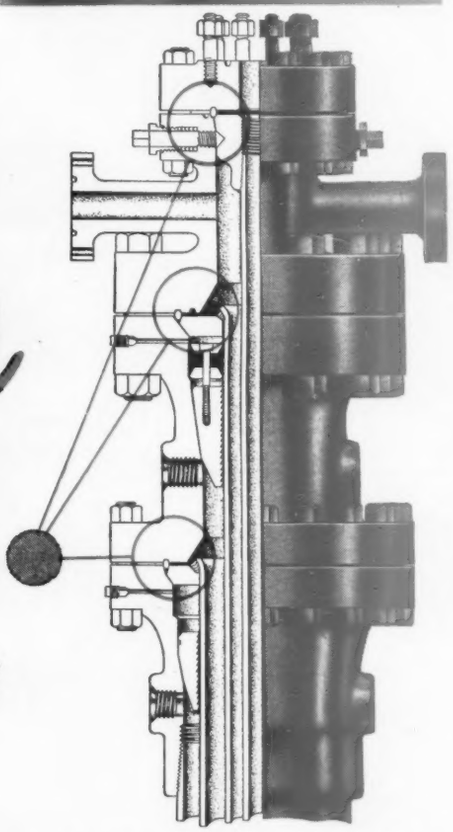

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majors operate water flooding projects. Formations being successfully flooded are most of the Pennsylvanian sands, Mississippian, Viola, Simpson, and Arbuckle. No further discussion will be made about secondary recovery except to say that the projects are not the reason for the "new boom." There appears, however, to be plenty of opportunity to set up new floods as the prospects they offer are by no means exhausted.

We conclude that leases in East Kansas can be operated at a profit, but that, especially in the stripper area, the wells are small (with a few notable exceptions), and that the margin of profit is small. It is essential in both drilling and operating to keep costs at a minimum. Operators may be major companies or they may be local people who have drilled their own lands. The result is that over most of the area nobody knows for sure just what others are doing. Although latest scientific methods have been introduced and used successfully, very little data from these methods such as core analysis and electric logs are available to us.

Little application of scientific methods of exploration has been made, and this is one field in which great progress is possible, especially in the use of subsurface geological tools. Concentrated study of the Cherokee and Marmaton sands offers great opportunity for extending the areas now being drilled and for finding new secondary recovery projects. As more of the older fields are redrilled more information will undoubtedly come to light and the problems of the area be considered more scientifically.

Acknowledgments

We wish to acknowledge the help of the Kansas Corporation Commission and especially T. A. Morgan and Dwight Lilley in assembling the production figures and in supplying us with information relative to secondary recovery projects.

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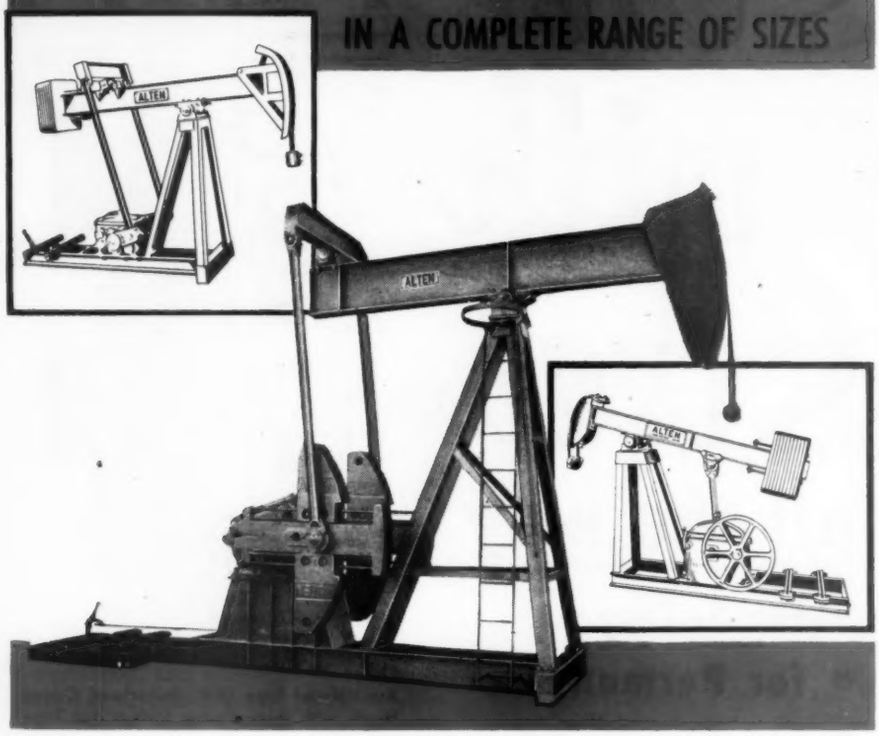

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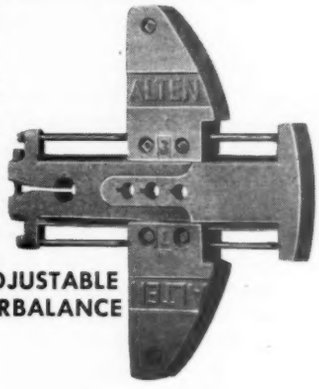

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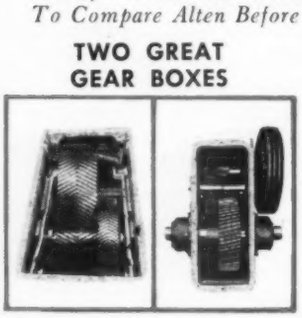

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Fracturing Pays Off in Hugoton Field

High injection rates appear to create several fractures within each pay zone

E. N. BENNETT and R. F. CASHEN

THE Hugoton field has now become an area of major activity for gel acid fracture treatments. Practically every known method of formation stimulation has been tried since discovery of the field. In October, 1952, the first gel-acid treatment was performed. Since that date, over 465 jobs have been completed in the Kansas and Oklahoma portions of the field. Continued popularity of the process is assured for new wells and future repairs of old wells.

History of Hugoton Field

Hugoton field, one of the largest gas fields in the world, covers nine counties in Kansas, plus a good portion of the Oklahoma and Texas Panhandle. Within the state of Kansas, the field stretches approximately 83 miles from north to south and is 54 miles wide at the maximum, covering over 2,000,000 acres or roughly equal to two and one-half times the area of Rhode Island. Within its three state limits, the field has a length of over 150 miles.

Major producing zones are limestones and dolomites within the Chase group of the Permian age. Some gas is also produced from the lower 30-40 ft of the Sumner group. Locally, Chase members are identified as the Herington, Krider, Winfield, Towanda, and Fort Riley formations, and are found at a depth of 2200-3000 ft.

The Chase group zones grade from clean limestones and dolomites in the south and east to a high percentage of clastic materials toward the west and north. These clastic materials are mostly shales and other materials which do not react to acid. The high clastic regions, where various acid and shooting treatments have not been too successful, are well suited for gel-acid treatments. Even on the east side of the field, where the clastic content is low, gel acid is enjoying a high degree of success. In fact, a fracture should always do as good a job as other types of stimulation. It is largely a matter of economics as to whether the increase in potential expected over a conventional acid treatment is worth the extra cost of the fracture job.

The discovery well in Hugoton field was drilled in 1927 with cable tools. Development progressed slowly due to lack of market for the gas. With the advent of rotary drilling and expanded gas markets, development increased and reached a peak in 1950. To date, over 3000 wells have been drilled in the Kansas portion of the field alone. Productive limits are now being approached, resulting in a development decline with about 200 wells per year being drilled.

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More than 2 trillion cubic feet of gas have been produced from the field since its discovery. Present recoverable reserves are approximately 13 trillion cubic feet.

Pre-Fracture Stimulation Methods

Throughout the development of Hugoton field, there have been many different methods, employed by operators in drilling and completing wells. Principally, two methods were used:

1. Set production string at top of Herington zone. Drill pay zones with cable tools and complete without stimulation. After hydrochloric acid came into use, the open hole pay zones in succeeding wells were acidized down the casing with about 100 to 125 gal of 15 per cent acid per ft of pay. These zones were then washed with 10,000 to 30,000 gal of 7½ per cent acid. Some operators ran liners in the open hole prior to acidizing to prevent caving and sloughing.

2. Set production casing through all pay zones or to the top of the lowermost zone. Cable tools were used to clean out to the desired depth. Some operators then perforated and squeezed the shale breaks between zones to make

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The Authors

E. N. Bennett R. F. Cashen

Eugene N. Bennett, field engineer for Stanolind Oil and Gas Company, received a B.S. degree from Missouri School of Mines and Metallurgy in 1947. Following his graduation he joined Stanolind in their Gorham, Kansas area office and was active in the development and production of oil.

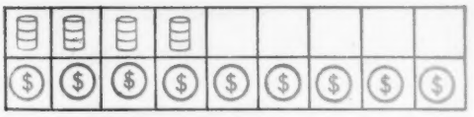
Robert F. Cashen is a petroleum engineer in the Kansas district office of Stanolind Oil and Gas Company at Ellinwood, Kansas. A graduate of Brown University, Cashen joined Stanolind in 1948 and has been active in the Ark-La-Tex and Mid-Continent regions.

later selective acidizing more effective on the limestones and dolomites. The lowermost zone, either open hole or perforated, was acidized down the hole with 2500 gal of 15 per cent hydrochloric acid. Each of the upper zones were then perforated and selectively acidized. The well was then acidized down the hole with a 6000-12,000 gal 7½ per cent acid wash. In many areas, additional wash shots of smaller volume were performed on the well if productivity increases were achieved. Wash shots sometimes approached 30,000 gal of 7½ per cent acid.

Open hole completions were generally performed in those areas where it was believed that no water would be encountered. Casing was set through the pays to achieve more selective acidizing and to facilitate shutting off water production where necessary.

As development progressed, special acid additives, such as low surface tension agents, inhibitors, and silicate swelling preventives were used. Variations in the sequence of high concentration and low concentration acids were also performed.

Later drilling along the north edge of the Hugoton field in the high clastic area indicated that conventional acid treatments were not very successful. Several operators attained successful completions by shooting the pays with nitro glycerine. Procedure consisted of setting pipe on top of the Herington, cleaning out to the base of the Krider, or Winfield, if it was to be shot, shooting pays with liquid nitro glycerine, cleaning out, drilling deeper if desired (to base of Towanda), running a loose liner and acidizing with 2000 to 10,000



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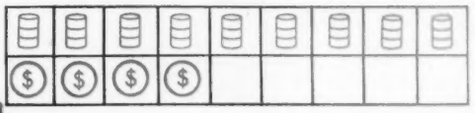

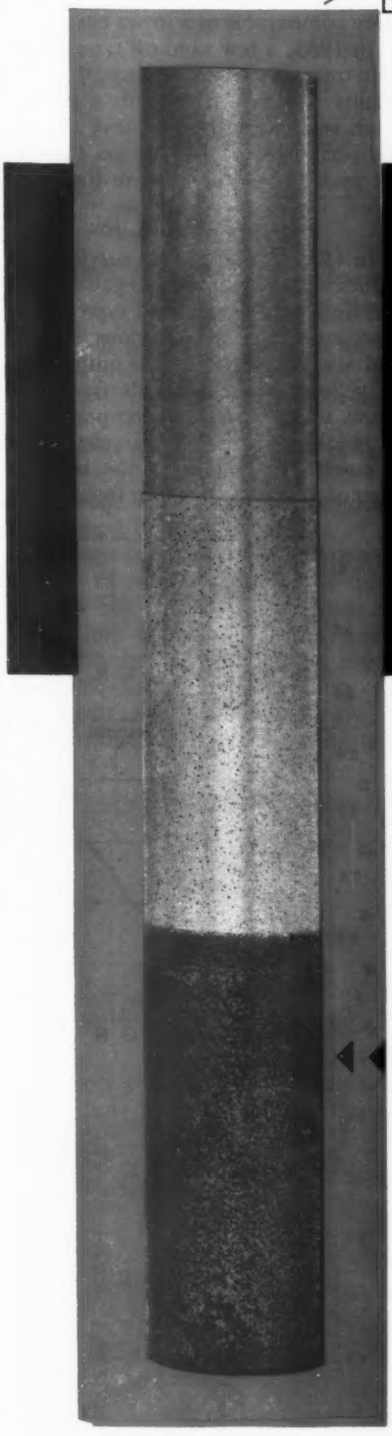

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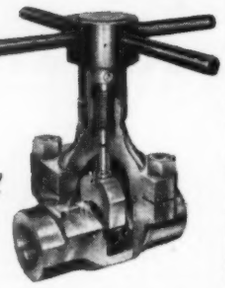

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gal of 15 per cent acid and washed with 4000 gal of 7½ per cent acid. It was noted that the acid treatments in this region resulted in only a 5 to 10 per cent addition increase in production. It was apparent the efficacy of acid treatment in high clastic areas was quite limited.

In an attempt to find a more satisfactory treating method for the high clastic areas, gasoline base Hydrafrac treatments were performed on a few wells. It was found, however, that results from conventional acidization were comparable at a lower cost.

In 1953, a few sand-oil type Hydrafrac treatments were attempted but the results were erratic. Usually a gasoline wash was necessary to relieve the partial permeability block to gas that was set up by heavy oil used in treatment.

Fracture Stimulation

In 1952 and 1953, the service companies and operators began experimenting with gelled acid type Hydrafrac, consisting of a viscous acid gel and suspended sand. The importance of gelled acid type Hydrafrac treatments was apparent during one of the early jobs performed in January, 1953. The well, located along the northern edge of the field, had been treated with conventional acid and proved to be non commercial. A gel acid fracture treatment was performed resulting in a commercial producer.

During the treatment, the formation is hydraulically fractured by the viscous gelled acid and propped open with the Ottaway sand left in the fracture. The viscous gel breaks down to a liquid state and is flushed out of the formation. The acid content of the fracturing media assists in increasing the permeability by dissolving the lime and cementing materials around the sand grains and clastics in the formation.

As in the case of conventional acidizing, slight variations are employed by each operator in their respective fracturing procedures. Some operators set pipe on top of the bottom producing zone, open hole treat through tubing using an initial diesel fuel break shot with low surface tension chemicals. This is followed by a diesel oil spacer and 2000-3000 gal of 7½ per cent gelled acid with two pounds of sand per gallon. Finally, the treatment is completed with 1000-1500 gal of 7½ per cent acid with low surface tension agents added. After swabbing down and testing the lower zones, the upper zones are perforated and selectively treated through tubing and straddle

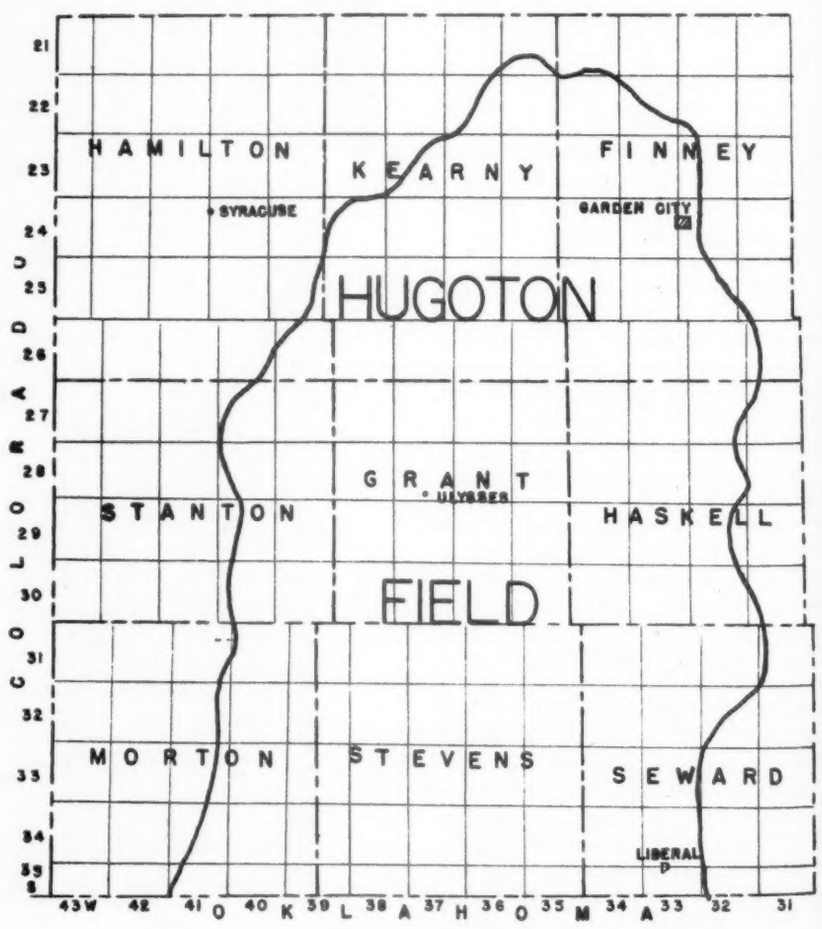


FIG. 1. The Kansas portion of the Hugoton gas field.

packers similar to open hole treatment.

Some operators prefer to set production casing on top of the Herington and drill deeper to total depth with cable tools to keep mud filtrate water from the clastic pay intervals. All of the zones are then treated down the casing with one large gel acid treatment (6000-10,000 gal with 3000-20,000 lb of sand) followed by one-half of the above volume of 7½ per cent acid with low surface tension agents. During displacement of the wash shot, care is exercised to prevent entry of water in the formations. Other operators set production casing to rotary total depth and selectively treat each perforated zone through the tubing with similiar quantities of gel acid, 7½ per cent acid wash shots, and low surface tension chemicals. A few Hugoton operators prefer to treat the lower perforated zone or open hole through the tubing and the upper perforated intervals at the same time down the casing.

The majority of operators now prefer high injection rates which require heavy duty pumps to inject the viscous gel. As each month goes by, larger and more powerful pump trucks are being provided by the service companies. It appears that high injection rates result in the viscous gel creating several fractures within each geologic pay formation. Also, the gel is forced quickly back into the fractures prior to the acid reaction. Slow injection rates probably result in only a few of the more permeable zones breaking down and being treated. In practically all instances, the operators are now adding low surface tension chemicals to acid washes to aid in breaking down the viscous gels and cleaning up any permeability blocks that may have formed.

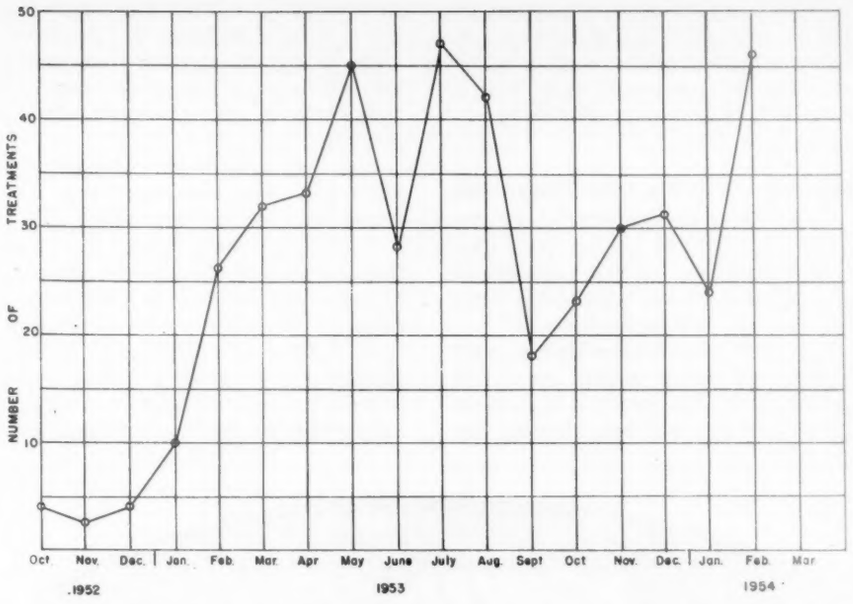
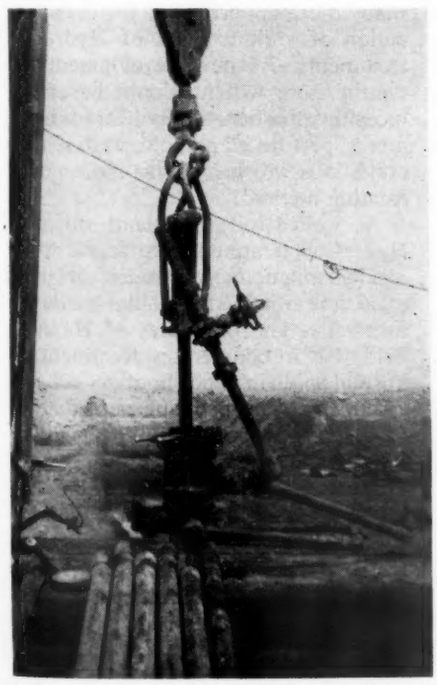


FIG. 2. Number of gel-acid fracture treatments performed since initial job in October, 1952. Normally two such treatments are performed on each well.

Generally, all operators are using 2000-4000 gal of gelled acid per geological pay interval. Some prefer one-half pound of sand per gallon, others one pound of sand per gallon of gel, while most operators are now using two pounds of sand per gallon. All operators are now using a 7½ per cent acid wash shot with low surface tension chemicals immediately after the gel acid with sand.

Combination conventional acid and gel acid treatments are also being done where drilling sample cuttings and electric and radioactive logs indicate one pay contains clear carbonates which will readily acidize while another pay may contain principally clastics which will require fracturing and treating with gelled acid. Also, some companies prefer to treat first with acid and then treat with gelled acid.

To date, more than 465 gelled acid, or acid frac, treatments have been performed in the Kansas and Oklahoma portions of the Hugoton field with the great majority of the jobs being in the Kansas area. Generally, two separate treatments are performed on each well:



Well head connections typical of those used for gel-acid fracturing in Hugoton field.

Acid transport and pump unit hooked on to flush oil tank.

One for the bottom zone, and one for the upper zones. Fig. 2 presents graphically a history of the number of gel acid fracture treatments performed to date in the Kansas and Oklahoma portion of the field.

Significance of Fracture Stimulation

It is still too early to predict the ultimate benefits to be gained from fracture treatments. Certain advantages are apparent already while other benefits can only be estimated.

Gel acid treatments are ideally suited to the high clastic content portion of the reservoir. The success of conventional acidizing has been limited due to the lack of acid reacting material in the reservoir. Shooting has been partially successful, but the force necessary to create fractures is not controlled sufficiently to create extensive lateral fractures.

Gel acid, in its thickened state, provides four main advantages over conventional acidizing or shooting.

1. The high viscosity and low penetration rate allows the impression of sufficient pressure on the formation to break it down and create or possibly open fractures, providing more and larger passages for the gas to get to the well bore. Such pressures can be obtained with the normal equipment used by service companies. To get the same effect with conventional low viscosity acid would require much higher input rates.

2. Gel acid treatments require only about one-half of the injected liquid volume comparable to a conventional acid job. Consequently, the formation is purged of the liquids more rapidly, requiring less blowing to the atmosphere with its attendant waste of gas. While insufficient data are available yet, it has been noted that some fractured wells have more stable flowing characteristics when first turned into the pipeline which results in a saving of pumpers' time. No doubt this is also partially due to the smaller volume of liquids injected into the formation.

3. Gel acid has a slower reaction rate than normal acid. Thus, acid does not become completely spent in the area immediately around the well bore but continues to react on the carbonates along the sides of the fractures, opening more effective porosity to the well bore.

4. The viscous gel provides a good carrying agent for the sand, that is used to prop open the fractures created by the gel. Without the sand as a propping agent, it is reasoned that the fractures could partially close again, after the injection pressure is released.

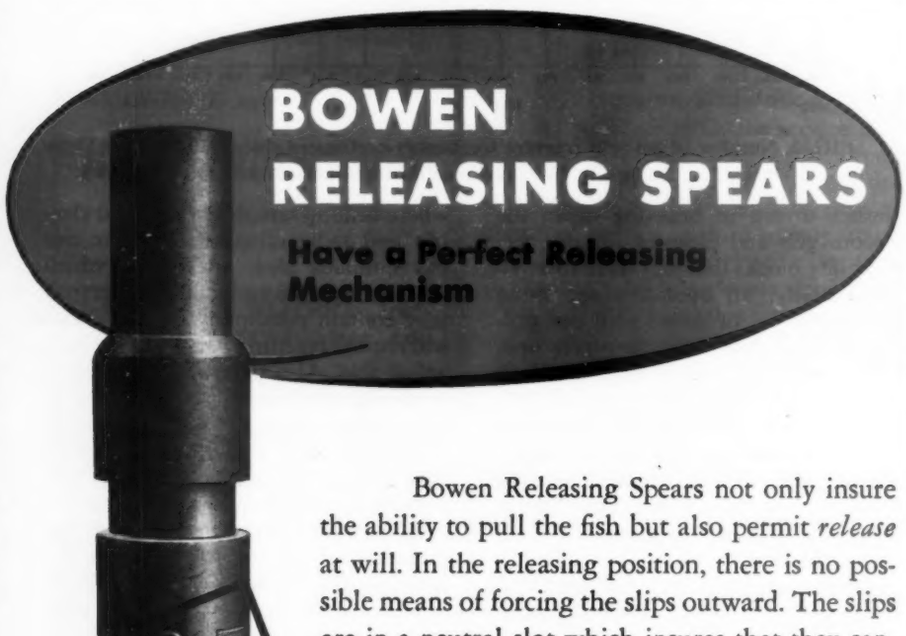
The above features have served to obtain the additional gas deliverability and recovery from the marginal high clastic areas. In fact, the use of gel acid has even extended the productive limits in these areas.

At present, there are many low capacity wells in the Hugoton field that were completed prior to the advent of gel acid fracturing. Such wells offer many more opportunities for the application of various types of Hydrafrac treatments. As new development declines, there will no doubt be an increasing number of Hydrafrac treatments performed on old wells where conditions will justify this more costly treating method.

As gelled oil and sand oil type Hydrafrac treatments are found to be ideally suited to sandstones, gel acid (acid frac treatment) is tailor made for limestones and dolomites of Hugoton field. As a companion treatment to normal acidizing and shooting, gel acid fracturing can take its place in the history and development of the field.

Acknowledgment

The authors wish to express their appreciation to personnel of Acid Engineers, Inc.; Dowell, Inc.; Halliburton Oil Well Cementing Company; and The Western Company for their cooperation in furnishing data for this paper. The authors also wish to express appreciation to Stanolind Oil and Gas for permission to publish the paper. * *



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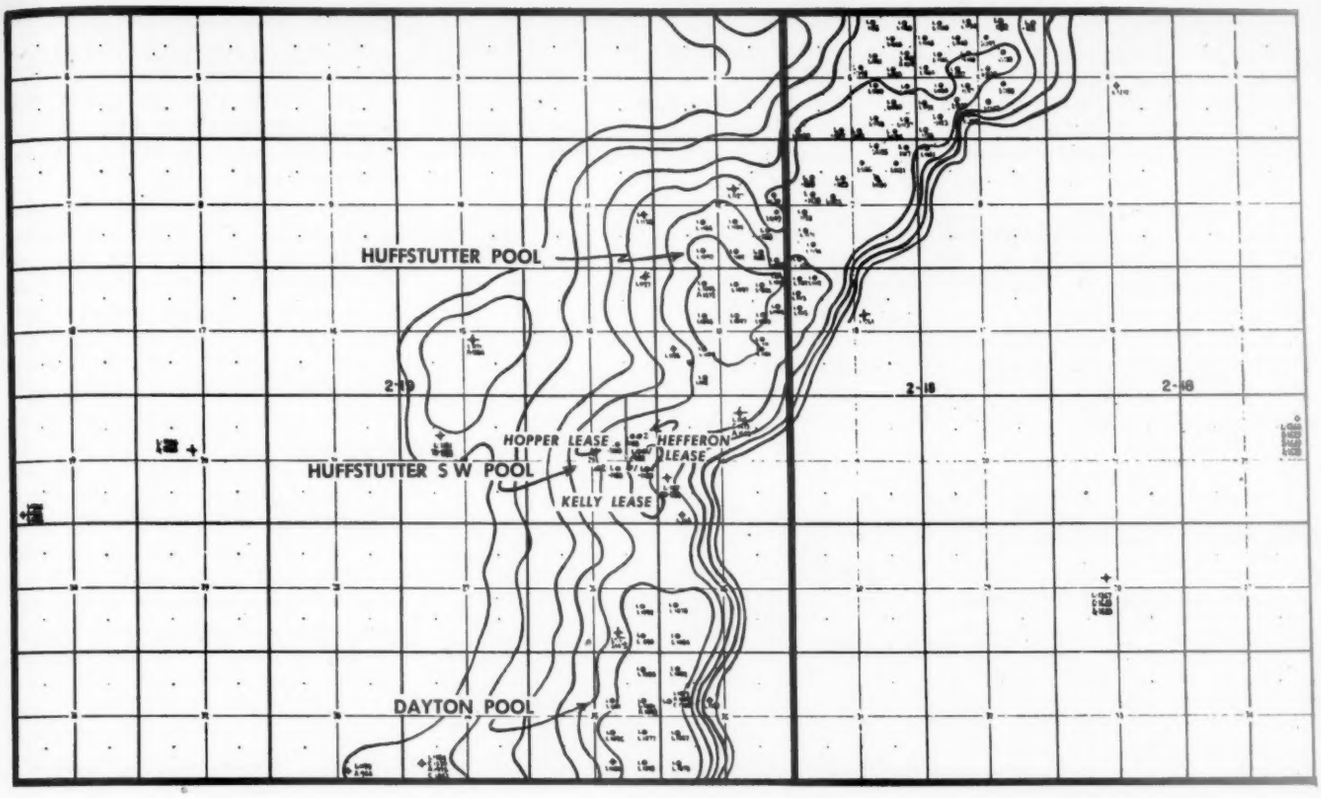

Completion Difficult in Huffstutter Field

Southwest pool presents serious problem in completing wells — 20-step program has been worked out

HIRAM W. LEWIS, JR.*

THE Huffstutter Southwest pool was opened by Lewis Drilling Company of Wichita, Kansas, in June, 1951, with completion of the Kelly No. 1, Sec. 23-2S-19W, Phillips County, Kansas. Subsequent development resulted in five wells, all producing from the Lansing-Kansas City. Producing zones are: Top of Kansas City, 90-ft zone, and 150-ft zone. Average gravity of the oil is 33 deg. As of April 1, 1954, these 5 wells have produced a total of 77,500 bbl of oil, and total daily production is currently 96 bbl per day. The Huffstutter Southwest pool is not considered by the author to be fully developed; however, further development is being postponed until long-range results of remedial and final completion work done in January and February, 1953, are known.

Rotary drilling in the Huffstutter area has presented no serious problem to date. Average drilling time from move in to move out is 10 days to the base of the Kansas City at approximately 3500 ft. Seven rock bits and $400 mud bills are average. Water must be hauled but can be readily obtained for $500 to $600 per well. No lost circulation or crooked hole trouble has been encountered. Nearest point of general oil field supply is a Plainville, 50 miles to the south. Supplies such as fuel, etc., can be obtained at Phillipsburg, 10 miles south of the pool.

Marketing the oil produced in this area presents no problem as Cooperative Refinery Association operates a refinery at Phillipsburg, thus providing a ready market for the oil produced.

Completing wells as a producer after setting the oil string presents the only serious problem to the operators in the Huffstutter area. for reasons not yet established, it is extremely difficult to obtain a solid cement job on the oil string. Upon perforating and acidizing individual zones, communication is established between oil zones and also with a water zone approximately 60 ft from the top of the Lansing. Lack of a good bond between the cement and the wall of the hole also allows acid to bypass producing zones and enter shale zones that require less pressure to break them down than the producing zones. The completion plan finally worked out by the operator calls for a 20-step program as follows:

1. Set surface casing at 160 ft; cement with 125 sacks cement, 2 per cent calcium chloride.

2. Drill out under surface to approximately 3000 ft with clear water and native mud. Mix sufficient mud and chemicals to reduce water loss to 15 cc, weight to 10 lb per gallon, viscosity 38. This mud is maintained to total depth of the well.

3. Drill stem test oil zones as encountered. Typical drill stem test is

*Lewis Drilling Company, Wichita, Kansas.

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100 ft heavily oil-cut mud, bottom hole pressure 800 lb.

4. Upon reaching total depth, run Schlumberger Microlateral Log.

5. Set 5½ in. casing on bottom, working casing up and down while cementing. 125 sacks cement are used. No centralizers or wall scrapers are used as they are ineffective.

6. Swab hole out and run gamma ray curve and collar log.

7. Match gamma ray and collar log to Schlumberger log.

8. Perforate between 150-ft zone and 90-ft zone; perforate between 90-ft zone and 60-ft water zone.

9. Squeeze through tubing with 200 sacks cement staged to 3000 lb final pressure.

10. Immediately perforate between 60-ft water zone and top zone, perforate above top zone.

11. Squeeze through tubing with 300 sacks cement staged to 3000 lb final pressure.

12. Drill out cement after 72 hours.

13. Perforate 150-ft zone with 4 shots/ft.

14. Acidize through tubing with 3000 gal Dowell 15 per cent acid.

15. Set Lane Wells plug above squeezed perforations and below 90-ft zone.

16. Perforate 90-ft zone, 4 holes/ft.

17. Acidize through tubing 3000 gal Dowell 15 per cent acid.

18. Set plug above squeezed perforations and below top zone.

19. Acidize through tubing with 3000 gal Dowell 15 per cent acid.

20. Drill out Lane Wells plug, run tubing and rods.

Originally, the first well was completed in the 150-ft zone only, the second well in the 90-ft zone only, and the third well in the top zone only. These zones were then produced independently for a period of approximately one year in order to establish initial production decline and leveling off points of the individual zones. All zones reacted approximately the same, initial potentials being 100 bbl per day dropping rapidly during the next six months to about 10 bbl per day.

In January, 1953, the operator moved in a re-conditioning unit and fully completed these wells. After experiencing the original flush and rapid decline, these wells leveled off approximately 30 bbl per well with two exceptions—the Kelly No. 2, which was structurally low and the Heffron No. 1, which mechanical difficulties prevent producing below the top zone at the present time. The operator as yet has not been able to isolate the 60-ft water zone in the Heffron No. 1. As soon as satisfactory water disposal arrangements are made, it is expected that this well will produce in a similar manner to the other wells; however, approximately 150 bbl of water per day will have to be lifted along with the oil.

All wells in the Huffstutter Southwest pool are equipped with 2 in. tubing, ¾ in. sucker rods, and 12 hp pumping unit and engines. Tank batteries uniformly consist of one 210-bbl wood gunbarrel and two 210-bbl welded steel storage tanks.

Operating costs in the Huffstutter area are relatively low due to not having a major salt water problem and the fact that the light nature of the wells keeps at an absolute minimum service unit time, replacing rods, tubing, and pumps. To drill, complete, and equip an average well in the Huffstutter Southwest pool costs approximately $45,000. Recoveries are expected to average 50,000 to 55,000 bbl per well on 20-acre spacing.

In view of the high completion cost and only mediocre recovery, a high margin of profit cannot be expected from operations in this area. This condition is partially offset, however, because of high gravity oil, low operating cost, and the available market for the oil at the Phillipsburg refinery.

All factors considered, the Huffstutter Southwest pool presents a typical picture of operation in an average Kansas City oil pool of north central Kansas. * * *

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Secondary recovery through an "in reservoir" combustion process promises almost complete production of all formation oil, author states

Flame Flooding

FRANK G. BUFFUM

RECOVERY of billions of barrels of oil remaining in oil-bearing formations after depletion by primary production methods and successive secondary oil recovery techniques, such as waterflooding has been the goal of many reseachers, who now include not only engineers and physicists but also chemists. It has presented a real challenge to the inventiveness and ingenuity of the petroleum industry.

It has been estimated that of deposits aggregating over 175,000 million barrels of oil known to have been contained in oil fields discovered in the United States up until 1951, 64,000 million barrels have already been recovered by primary methods and a further 4,000 million barrels by existing secondary techniques. Thus the precise whereabouts of 107,000 million barrels of American petroleum deposits are known, but proved reserves out of this residual total are estimated by the American Petroleum Institute at only 29,536 million barrels capable of production by existing secondary oil recovery techniques, with a total of 77,464 million barrels officially deemed "unrecoverable."

This does not take into consideration tremendous deposits of oil contained in shale deposits in the United States, nor in the low gravity low viscosity sands of Northern Canada where in one tract containing some 350,000 acres oil in place has been estimated at from one to three hundred billion barrels.

Fire flooding was initiated originally with the goal of recovering at least a small part of these known "unrecoverable oil deposits," after exhaustion of the abilities to produce by other established secondary recovery techniques. Actual attainment of this goal beyond all expectations, however, serves notice that such intermediatory efforts will eventually be discontinued and "fire flooding" utilized to supersede "waterflooding," eliminating the high intermediate costs in favor of decreased initial costs of development and operation and greater recovery.

Flame flooding is basically the ignition of the oil-bearing sands, which is accomplished by various methods. Magnolia Petroleum Company prescribes use of an electric heater which, after ignition of the sands, is removed. Sinclair utilizes a gas burner arrangement that is lowered into the inlet well for the same purpose. A third method utilizes an incendiary "fusee." Combustion is supported in the ground by pumping oxygen in the form of compressed air down the inlet well. As the combustion front progresses slowly through the oil-bearing sand the heat produces energy that forces the migration of the oil ahead of the combustion front to migrate to the outlet wells. As the heavy ends of the oil adhering to the sand cannot escape the combustion front these are consumed, utilizing for purposes of combustion approximately 10 to 15 per cent of the oil in place to produce a calculated 85 to 90 per cent of the oil in place, a much higher percentage than is produced by any other secondary recovery method. Through consumption of the heavy ends of the oil, the oil produced is naturally of better quality and higher gravity, which offsets this small combustion loss.

Use of fire flooding in old oil fields that are still marginally producing primary oil (where water flooding is being contemplated) offers not only tremendously increased production potentials but saving in development and operating costs. Some of the old wells may be used as fire inlet wells, thus eliminating expense of drilling multiple water inlet wells, establishment of pumping stations, and of obtaining and maintaining adequate water supply. As energy is derived from combustion of a very small portion of the oil in place (in fact much less than would normally be abandoned as "unrecoverable" in a conventional water flooding operation) operational expense is more or less limited to supplying of compressed air to

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The Author

Frank G. Buffum has had successful careers as an inventor, organizer, and engineering salesman. After serving in the first World War, he went to work for his father's Buffum Tool Company at Louisiana, Missouri. Later he enrolled in Columbia University, specializing in business management, economics, and commercial law, while working for Merrill Lynch and Company as a salesman.

Completing his studies he returned to Louisiana, Missouri, and purchased the Lynott Stove and Churn Works. With the merger of Buffum Tool Company properties in 1930, he formed the United States Tool Corporation.

In 1939 Buffum developed and perfected "bi-metallic iron" when employed as a sales engineer with the Illinois Malleable Iron Company. Later he served as general manager and also sales manager with various companies. He later formed his own company to engage in general sales engineering and he perfected a process for manufacturing of newsprint from waste paper.

Buffum became interested in secondary recovery of oil when with the Plymouth Corporation and developed the Schrapp process, later doing research in secondary recovery by sub-surface blasting oil-bearing strata through hydrogen blasting. To continue this work the Stratablaster Service Corporation was formed. Although tests were successful, results were not of commercial importance.

Believing that reservoir energy could be attained by ignition of oil bearing sands, Buffum developed a technique that did away with the massive equipment and elaborate procedure. It needed only the selection of one or more center producing wells, an incendiary fusee, and the pumping of compressed air down the well to maintain combustion.

At present Buffum is negotiating to go into flame-flooding development on a large scale and plans to buy old properties in Kansas-Oklahoma-Texas territory, whether on marginal primary production or considered already water-flooded out, and convert them to flame flooding.

XUM

maintain the combustion front.

By using present oil output wells in water-flooded properties, as fire input wells, and water input wells as oil output wells the flow is reversed, eliminating expensive drilling operations. It does not appear that the water content in the sands provides any major problem as water is driven ahead of the combustion front, and eventually cleared from the formation, producing the residual oil in place.

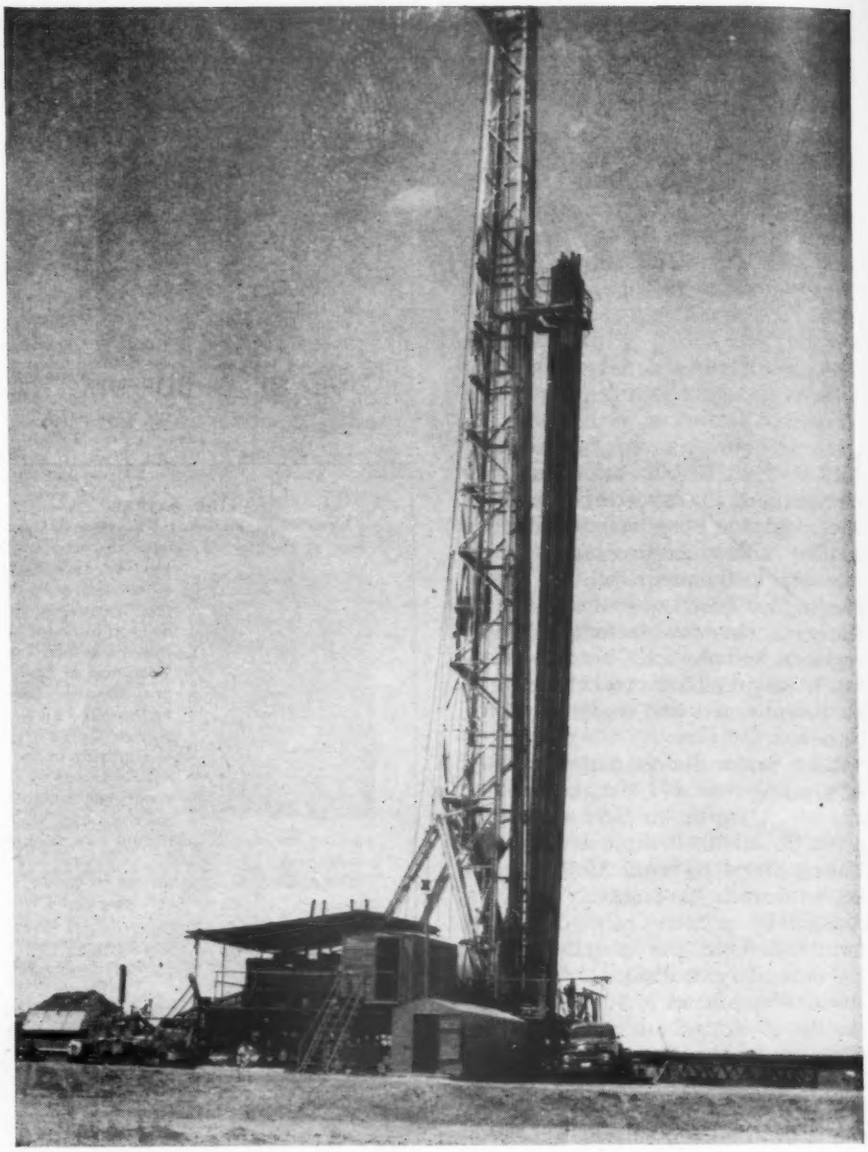
Although the effective speed of fire flooding as compared to water flooding has not as yet been too definitely established, it is estimated that increased production becomes apparent within a much shorter period of time requiring from 90 days to 6 months, and that production will be maintained for a much longer period of time on a "peak" basis.

Use of fire flooding to supplement drilling operations for primary oil will follow as night follows day. There are tremendous known deposits of oil contained in areas lacking reservoir energy and contained in sands of low porosity and permeability, and although the total amount of oil in place may be tremendous, primary production may be marginal and the characteristics of the oil-bearing formations such as to discourage other secondary oil recovery techniques. It seems to make little difference in fire flooding of such sands as the combustion front apparently burns through these sands just as effectively as it does through the more porous and permeable sands.

One interesting aspect of flame flooding is the by-products attainable, and probably these eventually will be developed on a very large scale. Every day millions of barrels of crude oil are transported from the oil fields by tank car and pipe line to plants throughout the country where they are burned to obtain by-products of combustion. It is already evident that by control of air introduced into the fire wells the amount of unconsumed hydrocarbons may be controlled and that, in addition to tremendous quantities of natural gas that may be produced from the outlet wells, these gases may be run through treatment plants and the by-products of combustion be obtained at negligible raw material cost. Natural gas becoming a tremendous reserve as fields become depleted. * * *

Venezuela Production

Creole Petroleum Corporation, the largest producer in Venezuela, is currently producing about 740,000 bbl of oil daily. Shut-in production is about 150,000 daily. Creole accounts for about half the 600,000 bbl a day U. S. imports from Venezuela.



Rig on Helmerich and Payne No. 16 Jones.

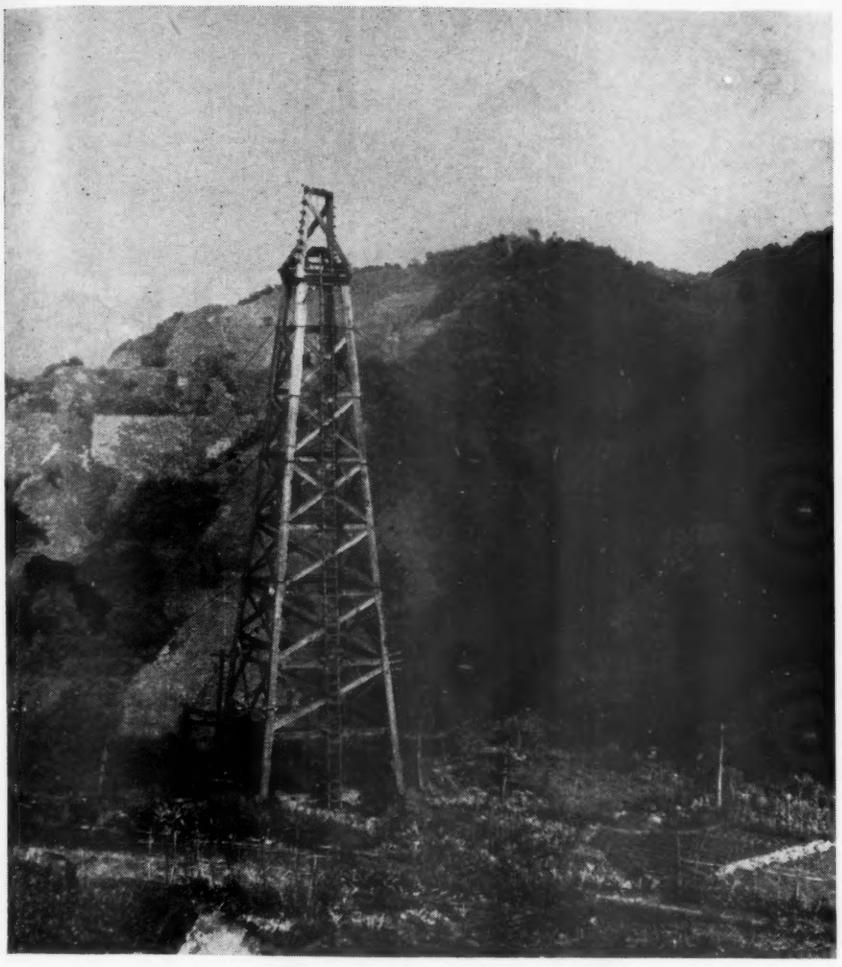
First Oiler Completed in Haskell County, Kansas

First oil producer in Haskell County, Kansas, is Helmerich and Payne's Jones No. 16. Although the Hugoton gas field, one of the largest in the nation, is in Haskell County, oil until now has not been produced. The wildcat was drilled to a total depth of 5100 ft and has 7-in. casing set at 5081 ft. It is producing from open hole at a depth of 5082 to 5100 ft in the Mississippian formation, which was stopped at 5041 ft.

A Kansas state potential test averaged 7 bbl of oil per hour. The state allowable is 43.70 bbl per day. Oil produced from the well is being purchased by the Shamrock Oil and Gas Corporation.

Helmerich and Payne are highly pleased with this discovery and feel that future development will prove up considerable reserves.

A second possible oil field for Haskell County has been indicated at Bennett and Roberts' No. 1 Boatwright. This wildcat is five miles northeast of Sublette on the east flank of the Hugoton gas field. On a recent drill stem in the Pennsylvanian-Lansing formation 200 ft of oil was recovered. * * *



Pumping well at Chuhuangking (Shukkoko) oil field in central Taiwan. The rugged terrain is typical of most of the fields in Formosa.

The author has recently accepted an assignment for one year as petroleum geologist with the United Nations Technical Assistance Mission to Taiwan (Formosa). He will advise and assist the Chinese National Government in exploration and development of petroleum resources.

First Postwar Exploration Success in Formosa

LEO W. STACH

Testing of the Chinese Petroleum Corporation's Chutauchi R-8 well, in Central Formosa, which began on January 18, yielded about 50 bbl daily of light crude by swabbing during the last half of January. Well flowed intermittently at about 30 bbl daily and has been pumping about 60 bbl daily of light paraffin-base crude (38.9 API) with a gasoline content of 35 per cent since mid-February. Crude is being produced from about 50 ft of fractured sandy mudstone at a depth of about 2600 ft, but this zone is believed to be above the original target horizon, so that deeper zones may be present. Although by most standards production is small, it is significant locally when it is considered that Formosa's total production of crude since the war has averaged only about 50 bbl daily, mostly from about 25 producing wells in the old Chuhuangkeng (Shukkoko) field.

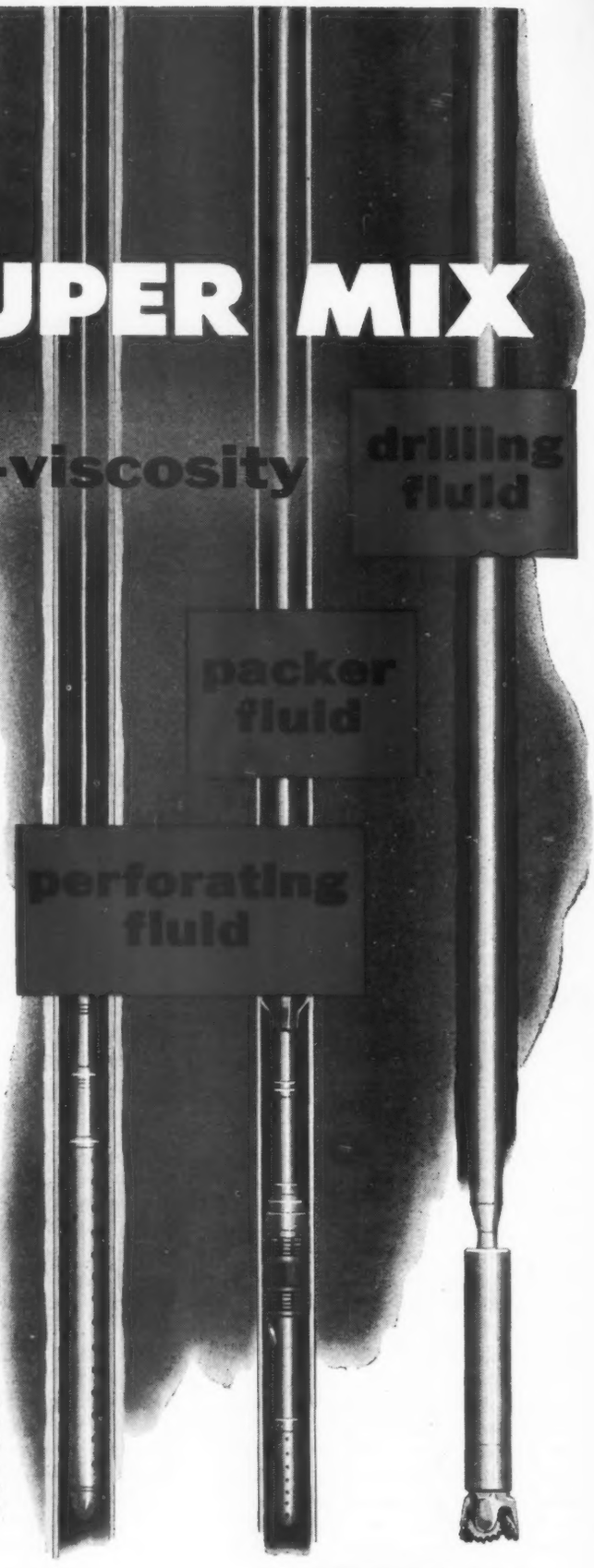
The successful test well is located about one mile north of the old producing area of the Chutauchi (Chikutozaki) field. Two of the seven wells drilled before and during the war still produce a total of about 50,000 cu ft of gas daily from an area low on the southern plunge of the narrow elongated Chutauchi structure, which has a total length of about 18 miles. Location of the successful extension well, although structurally much higher than the old wells, is still far from the main culmination that lies in very rugged terrain making development difficult.

This success marks the first tangible result from the exploration program begun two years ago by the government owned Chinese Petroleum Corporation (CPC) with the encouragement of the FOA Mutual Security Mission to China, that during this time was headed by Dr. Hubert G. Schenck, well known stratigrapher and paleontologist formerly of Stanford University. Early in 1952 Leo W. Stach, an Australian geological consultant based in Tokyo for oil and gas development work in the Far East, was invited to Formosa by CPC to recommend a program of exploration and development. In spite of its limited resources CPC undertook new geological surveys, drilled two exploitation wells in Chuhuangkeng (Shukkoko) field to obtain reliable subsurface data, and drilled their first well in a new area at Fanpokeng on a higher culmination on the Chutung structural trend. This first wildcat, however, penetrated the steep flank of the structure before reaching the target depth, and operations were suspended pending further study.

Successful results at Chutauchi, which hold promise for development of a potentially large productive area, will do much to stimulate efforts to reduce Formosa's dependence on crude oil imports and may in the future become quite a significant factor in the island's economy. * * *

BLACK MAGIC SUPER MIX

a high-weight, low-viscosity drilling fluid



Here is a new, low-viscosity oil base drilling fluid that can be weighted to extremely high weights, yet remains stable under high temperatures and pressures. Tests have been run for periods of four weeks under high pressures and at temperatures up to 400° F. with no adverse effects. It contains no clays or bentonites; problems of high temperature gelation are completely eliminated.

DRILLING AND COMPLETION FLUID

Due to its low maintenance cost and complete resistance to contamination from cement, salt, anhydrite, etc., Super Mix is the ideal fluid for drilling and completion work where high mud weights are required. During a recent workover job in the Gulf Coast Area, Super Mix was weighted to 17.0 lbs./gal. (127.5 lbs./cu. ft.) with a viscosity of 69 sec. API at 120° F. This mud was in use for six weeks and *the total treating cost was less than $300.00.* Weights as high as 18.7 lbs./gal. (141 lbs./cu. ft.) have been successfully used in the field. For drilling deep, hot holes, heaving shale, and other troublesome formations there is no fluid to equal Black Magic Super Mix.

PACKER FLUID

Super Mix is also being used extensively as a highly weighted fluid in the annulus above production packers in high pressure wells. In no case has the fluid shown any tendency to settle, disintegrate or solidify. When it becomes necessary to pull the packer, the Super Mix—unlike other packer fluids—serves as an ideal drilling or workover fluid. It can not deteriorate by standing idle for long periods of time.

PERFORATING FLUID

As a perforating fluid, Super Mix will not seal off the newly shot holes, as is the case when a fresh or salt water clay mud is used. The excessive heat and force generated by bullets and jet charges actually bakes a hard, solid clay plug behind the shot, thereby minimizing the perforating job. In some cases flow has been restricted as much as 77 %.* In recent experiments with perforating guns, Super Mix produced a soft mushy substance in shot holes which dissolved in crude oil when the well came on production. *No possible chance of plugging the formation with this drilling mud.* For more information on Super Mix, write for the paper—"Recent Developments in Oil Base Mud."

*Effectiveness of Gun Perforating, Journ. Pet. Technology, January, 1954.

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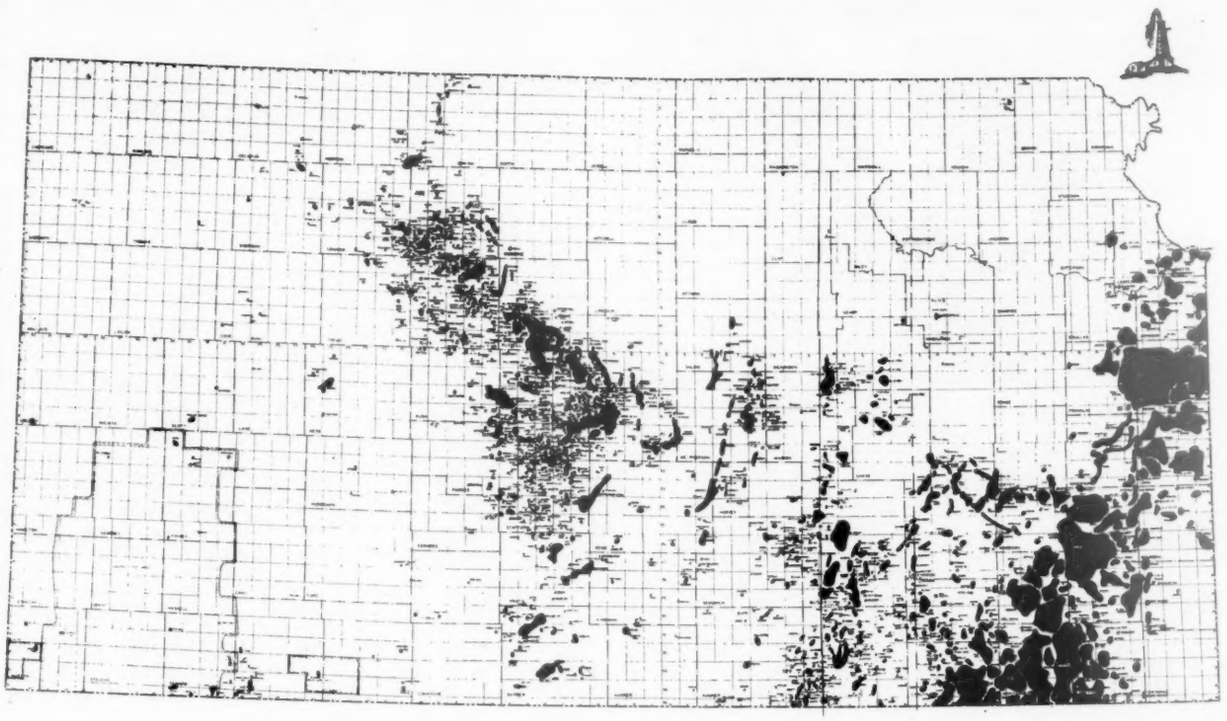

Courtesy Kansas Blueprint Company

Results of business-like handling of properties have meant steady and even spectacular gains in

KANSAS OIL PRODUCTION

D. H. SHOLTUS

KANSAS ran 114,390,176 bbl of crude oil to pipe lines in 1953. The daily average was 313,398 bbl. There were 5,039,444 bbl (42 gallons) of natural gas and liquefied petroleum gas including butane and propane) processed. Natural gasoline accounted for 2,978,066 bbl. Production of all grades of carbon black was 69,985,475 lb with a value of $4,454,197 at the plants. Gas production was 420,588,383 cu ft, including Hugoton. Hugoton produced 387,635,243 cu ft from 3101 wells.

West of Range 8 East, 1004 wildcat wells were drilled, 121 oil wells, 21 gas wells, and 862 dry holes. There were 3446 pool wells drilled, 1907 oil wells, 356 gas wells, and 1183 dry holes and salt water disposal wells. Total number of wells drilled was 4450.

East of Range 8 East, an estimated 4212 wells were drilled of all categories including water input wells. No record is available for the different categories.

Kansas has been divided into Western Kansas, West of Range 3 East, and Eastern Kansas, East of Range 3E, as there is a distinct change near this point in costs, drilling depths, and principal producing formations. In Western Kansas, 342 oil pools had produced over 100,000 bbl at the end of 1953. They are classed as follows:

22 — over 15,000,000 bbl
24 — 5 to 15,000,000
88 — 1 to 5,000,000
54 — 500,000 to 1,000,000
154 — 100,000 to 500,000

The pools below 100,000 bbl are in the process of development or developed since 1950.

The El Dorado pool of Butler County (Eastern Kansas) has produced over 200,000,000 bbl of oil. It is the outstanding pool of Kansas. With new methods of increasing production, use of secondary recovery and reworking wells, this pool in the future should produce as much as it has in the past.

EXCLUSIVE

Western Kansas

Advantages of oil production in Western Kansas are drilling depths, low costs, multiple producing horizons, per well recovery, and, of first importance, natural active water drives in most horizons. This is particularly true of the Arbuckle, the most important and prolific horizon to date.

In Western Kansas drilling depths vary from 2500 ft to 6000 ft at this time. The majority of the wells are drilled into the Arbuckle except in the Hugoton area. In Southwestern Kansas, the Arbuckle may be encountered at depths of 10,000 ft or more. The

The Author

D. H. Sholtus is district production superintendent for Kansas and Oklahoma for Great Lakes Carbon Corporation. He received his degree in petroleum engineering from the University of Oklahoma, and worked for Shell Oil Company and Phillips Petroleum Company before taking his present position.

Arbuckle is found at depths of 3100 to 5000 on or near the central Kansas uplift and the complimentary ridges.

Principal producing horizons are Reagan sandstone, Arbuckle, Simpson, Conglomerates, Viola, Kinderhook, Marmaton, Mississippian (principally cherts or "chats"), Misener, Hunton lime, Lansing-Kansas City (Pennsylvanian) 3 to 5 producing zones, some of the other Pennsylvanian sands, Morrow sand, Topeka section, Tarkio sand, Chase group (Hugoton gas) and others will be found.

The accompanying table shows the most prolific pools in Western Kansas. There is a large number of small pools of 10 to 20 producing wells, with average per well recoveries of 100,000 to 250,000 bbl. The western third of Kansas is in the exploratory drilling stage and offers attractive opportunities for prolific oil production. This is verified by the Morel pool, Norton pool, Damme pool, Ogallah pool, and the Morrow sand development. The Lansing-Kansas City zones are deeper and more prolific. The Hugoton gas area presents a very good opportunity for oil production.

The production and recoveries from the reservoirs, especially the limestones, cherts, and conglomerates cannot be accurately judged by core analysis, electric and radio active logs. Porosity is vugular and in the case of Arbuckle, it is also fractured. No method of core analysis has been developed to accurately calculate production or recoveries. Drillstem testing, with the attendant fill up, flow pressure and shut in pressure are of material assistance in analyzing production. No way has been found to determine accurately the pay thickness. Initial production both natural and after acidizing, and rates of fill up are very useful. Best method is to use average well recoveries by leases and pools in local areas. Principal reason is the active water drives present in most reservoirs.

Average lifting costs per barrel of oil for the life of a well are 55 to 65 cents based on today's prices. Lifting costs include:

Taxes, real, personal property and production; well servicing; company truck and auto expense; supplies and repairs; trucking; company and contract labor; supervision (foreman, subforeman, etc.); social security and other taxes; insurance; general lease expense; miscellaneous; cleaning out and reworking expense.

Until a few years ago an active water drive was considered a serious detriment to an oil property or reservoir and was reflected in the operations of oil producers. Today active water drives are considered very beneficial to low cost operations when properly handled. Proration has been of material assistance in the changes. Concepts of producing active water drive reservoirs has changed appreciably, as it has been learned it is a valuable tool with which to work. There is no cost for equipment or investment to make use of it. Costs involved are those for a disposal well, settling tanks, and lines. There is no cost for pressure maintenance. The reservoir maintains its own pressure. Secondary recovery and pressure maintenance require heavy expenditures for equipment, input wells and labor. Cost for a suitable disposal well and system to care for 10 to 20 wells is $35,000 to $50,000. Comparable secondary recovery on pressure maintenance will cost $70,000 to $100,000.

Proper handling of an active water drive will deplete a reservoir to a greater degree with less cost than other methods. Slow rates of withdrawal of oil per unit of time, 24 hours per day will recover more oil ultimately in active water drive pools. This method is being used more and more in Kansas. It also reduces other costs, such as repairs and replacements. The principle is to allow the water drive to keep pace with withdrawal and not bypass oil. In some pools, it will be necessary to assist the drive by injection of produced water at edges of the pool. Western Kansas having active water drives offers this opportunity to produce oil at low cost without secondary recovery or pressure maintenance methods and the attendant expenditures.

Pools West of Range 3 East 15,000,000 bbl or more.

County	Pool	First well	No. wells prod. at present	Daily avg. prod.	Total to 12/31/53	Principal producing horizon
Barton	Bloomer	5/35	295	4,831	42,912,470	Arb. LKC & Cong.
Barton	Kraft Prusa	5/37	740	12,045	65,904,953	Arb. & LKC
Cowley	Churchill	1926	.....	.....	Over 25,000,000	Stalnaker sand
Ellis	Bemis-Shutts	11/28	575	9,168	75,575,271	Arb. LKC
Ellis	Burnett	10/37	299	5,942	45,203,155	Arb.
Ellsworth	Stoltenberg	3/31	346	3,193	36,112,814	Arb.
Graham	Morel	4/38	213	4,286	16,646,038	Arb.
Harvey	Hollow-Nickell	12/31	39	323	20,919,833	Hunton
McPherson	Ritz Canton	7/29	179	1,491	43,178,064	Miss. Viola
McPherson	Voshell	8/29	56	516	28,531,187	Simpson
McPherson	Welch-Bornholdt	5/24	311	3,374	23,954,930	Miss. Cong.
Phillips	Ray	9/40	155	3,116	15,942,024	Reagan sd.
Reno	Burrton-Haury	2/31	327	1,994	48,169,275	Miss. Hunton, Viola
Rice	Chase-Silica	1/38 } 1/31 }	1371	14,849	175,215,338	Arb. LKC
Rice	Geneseo	6/34	257	4,713	34,212,058	Arb.
Russell	Fairport	3/24	200	2,118	25,057,016	LKC
Russell	Gorham-Big Creek	1/35	442	4,510	55,775,528	Arb. LKC
Russell	Hall-Gurney	2/35	1148	12,014	60,863,367	Arb. LKC.
Russell	Trapp	10/29	1343	14,996	143,275,580	Arb. LKC
Sedgwick	Valley Center	8/28	30	149	21,999,093	Viola (Kinderhook) Simpson
Stafford	Zenith-Peace Creek	9/37 } 7/41 }	193	919	38,352,636	Viola, Arb.

Eastern Kansas

Eastern Kansas has had a revival for the past two years in new development, as well as an expansion in secondary recovery projects. It presents good opportunities in both categories. Drilling depths vary from 200 to 2000 ft and wells cost from $2000 to $15,000 completed, depending primarily on depth and method of completion. Principal producing horizons are the series of Pennsylvanian sands. Artificial fracturing has enhanced opportunities in this area. The per well recoveries are comparable for other areas at those depths.

Summary

Kansas offers excellent opportunities in oil production, especially Western Kansas with its natural water drives at low costs and with high per well recoveries. In active water drive reservoirs, no secondary or pressure maintenance recovery methods are necessary with the attendant high expenditures for equipment and labor. * *

XUM

Fundamentals of Rotary Drilling

A TOOL FOR BETTER OPERATIONS

DRILLING Fundamentals is the result of a desire on our part to render the greatest possible service for those in drilling operations, which are so vital to the success of the petroleum industry.

The idea sprouted from a comment by a drilling contractor on the fact that his company provided regular talks to crews on location on the principles of drilling with the purpose of promoting safety and efficiency. Most companies do this, we know, but this remark happened to make us think about how much more valuable this information would be if the crew had the talks written down and could refer to them. That was the beginning of Drilling Fundamentals.

We talked to scores of operating men and wrote hundreds of drilling contractors, oil company men who specialize in drilling operations, suppliers of drilling equipment, and professors in colleges and universities who teach petroleum engineering.

At first we had only a brief outline of subjects to be covered. This outline was added to and revised. We have had three final copies mimeographed and, since the last one had only one change made, we feel it is pretty well organized and complete. Just the outline was six months developing. According to a consensus of the noted men in the drilling industry, this outline contains complete coverage of the subjects that are essential to safe, efficient operations.

These men, who are leaders in advancing the techniques of modern drilling, not only gave invaluable counsel on the subjects to be covered but many of them are contributing the chapters that make up the book on Drilling Fundamentals. They are the men who have added to the great fund of modern drilling methods and now give us the net results of their experience and knowledge in this compilation of the basic principles of rotary drilling.

The idea has been greeted with enthusiasm from all competent sources— from the drilling contractor who can improve training; from teachers of drilling methods in schools, some of whom have been writing their lectures as they go along; from experienced top hands interested in the last word from a group of specialists; from reservoir men who want a quick basic review of modern drilling for themselves and their crews.

And that brings us to exactly what type of reader will this series interest? It is written in a non-technical vein but without limiting the technical coverage. It includes the operations, the equipment and machinery, and the latest methods of modern rotary drilling. It can be used as a text book in schools, a manual on operations, a reference for old hands, and just plain, interesting reading for the big boss who made his stake working on a rig.

It presents a clear picture of the highly developed technique of oil well drilling for those with secondary but still important, interests in the operation, such as the geologist and geophysicist, the production superintendent and foreman.

It will help the boll weevil to do a better job and aid him to cooperate with others on the operation. It could prevent his injuring himself or others through not knowing what action his particular work calls for and what the equipment he works with can do. It is a series that first of all is for *use* — a tool for better operations.

Simply and briefly Drilling Fundamentals is for you — so that this important operation in the petroleum industry can with greater knowledge be done more safely, more efficiently, more economically. Drilling Fundamentals will stimulate the understanding and interest you need to make your job an adventure in advancement of better drilling.

Ernestine Adams

FUNDAMENTALS OF ROTARY DRILLING

Each subject is a separate article and some 50 operating authorities will each contribute one topic to the series. These will appear in The Petroleum Engineer during the year but not in the sequence below. They can be inserted in a loose leaf note book in proper order and when the series is complete, page numbers can be written in.

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AIR AND GAS DRILLING

K. M. Nicolson*

AIR and gas drilling, which is more accurately described as rotary pneumatic drilling, is the utilization of air or gas for the circulating fluid with conventional rotary tools. This drilling method has been successfully employed after cable tool and rotary hydraulic methods proved uneconomical or impractical for drilling under certain conditions. It is the purpose of this paper to discuss the fundamental characteristics of air or gas drilling, summarize the experience gained to date, and explain the factors considered in determining air or gas equipment requirements.

Characteristics of Rotary Hydraulic Drilling Method

The rotary hydraulic method provides the most economical drilling for the conditions found in the majority of wells drilled today. This is evidenced by the use of rotary tools on 71 per cent of the drilling rigs and 84 per cent of the wells drilled in North America in 1953. The characteristics of the rotary hydraulic method responsible for this superiority over cable tool drilling are:

1. Higher penetration rates in soft and medium formations.
2. Primary control of well pressure.
3. Better support for sloughing formations.
4. Means of directional drilling.

Under some conditions, however, rotary drilling is used to disadvantage because of the following characteristics:

1. The possibility of damaging formations due to drilling fluid and particle penetration.
2. The susceptibility to loss of circulation.
3. The tendency to contaminate cores and cutting samples.
4. The possibility of overlooking productive formations.

Characteristics of Rotary Pneumatic Drilling Method

The use of air or gas for the circulating fluid minimizes the four disadvantages listed above for rotary hydraulic drilling; however, two of the advantages are nullified as well, namely, the primary control of well pressure and the support for sloughing formations. In addition, air or gas drilling has in several cases shown an inability to cope with formation water, and in the case of gas drilling or "drilling in" with air, a considerable fire hazard is introduced. Thus, the important characteristics of rotary pneumatic as compared with rotary hydraulic drilling are:

1. Less possibility of damaging formations by drilling fluid and particle penetration.
2. Less susceptibility to loss of circulation.
3. Less tendency to contaminate cores and cutting samples.
4. Less possibility of overlooking productive formations.
5. Higher rates of penetration.
6. Longer bit life.
7. Less control of formation pressure.
8. Less support for sloughing formations.
9. Less ability to cope with formation water.
10. Higher fire hazard.

*Standard Oil Company of California, La Habra, California.

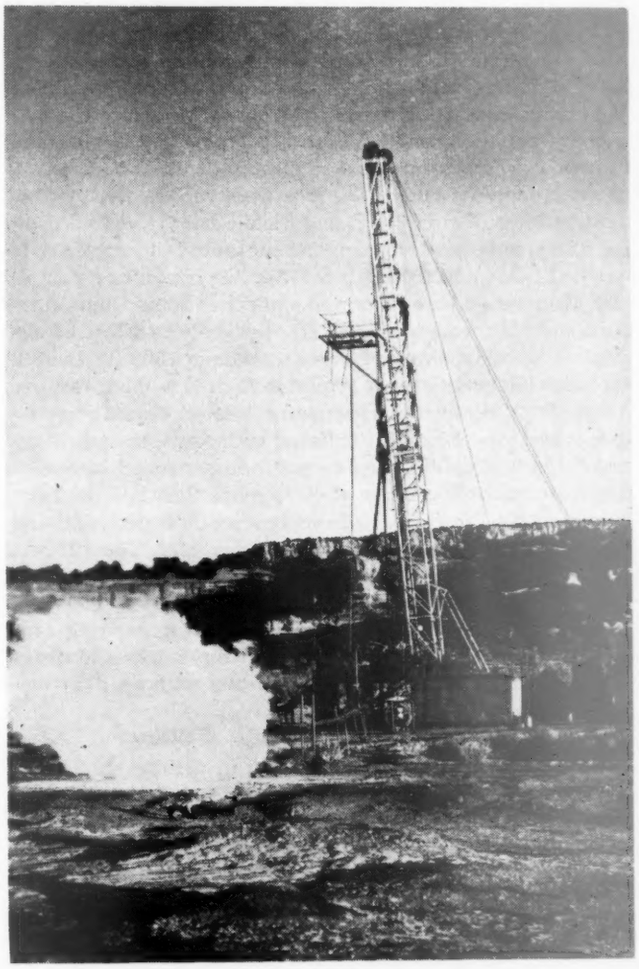
Applications of Air and Gas Drilling Methods

The scope of application of air and gas drilling is limited to certain conditions according to present-day concepts. However, in the future the field may be expanded as more experience is accumulated. Rotary pneumatic drilling has been used to a limited extent in the past[1,2] but its recent success started around 1951 — just 50 years after the first rotary hydraulic rig drilled at Spindletop. At present air or gas drilling appears to offer advantages where formations do not tend to slough nor contain appreciable amounts of water, and one or more of the following conditions exist:

1. Producing formations are susceptible to injury from drilling fluid or particle penetration.
2. Severe loss of circulation exists.
3. Drilling fluid is expensive or non-available.

San Juan Basin, New Mexico

Gas drilling has proven to be eminently successful in this area where the formation is conducive to loss of circulation and contamination by the wetting action of drilling muds. The Mesa Verde formation of the San Juan Basin consists of approximately 800 ft of alternating sands and shales



Drilling with natural gas in San Juan Basin.

topped at about 4700 to 5000 ft. Conventional rotary drilling was first tried for penetrating the producing zone and found to require 10 to 20 days and 8 to 10 bits. In addition the plugging action of loss of circulation materials on the producing formation definitely eliminated drilling with mud. Cable tools were then tried and often required 5 to 8 weeks to "drill in" the 800 ft of formation with practically continuous fishing jobs and waste of gas producing to the atmosphere. Gas drilling was then tried and "drilling in" cut to an average of 4½ days and 3 to 4 bits with a corresponding reduction in drilling costs and an overall saving of gas. The 6¼-in. and 6⅛-in. hole is drilled with an average gas volume of 2.2 mmcf per day and an average stand pipe pressure of 416 psig.[3,4] Operations successfully conducted with gas circulation in this area also include coring and directional drilling.

West Texas Area

Air drilling has been used in an attempt to improve completions in the Spraberry field of West Texas. The Spraberry formations have a very low order permeability and mud cake is detrimental to the productivity of these wells. Air drilling has improved this condition. The 6⅛-in. holes are drilled and cleaned out using 1 to 1.5 million cubic feet per day at pressures around 250 psig.[5]

Gas drilling has been successful in drilling below the surface casing from about 1500 ft to just above the pay zone at around 9500 ft in Val Verde County. An average of 1.5 million cubic feet per day gas at about 125 psig was used to drill the 8¾-in. hole. Compared with a mud drilled hole, gas drilling saved 17 days, 34 bits, and 34 trips in drilling from 1510 to 5321 ft.[6]

South Mountain, California

Air drilling has been applied successfully to combat severe loss of circulation coupled with limited water supply for drilling the surface hole in the South Mountain and Oat Mountain fields of California. At South Mountain the surface formations consist of highly fractured shales and broken volcanic formations to depths of 1200 ft. Conventional rotary methods proved expensive because of high mud and loss of circulation materials costs. Cable tool drilling consumed excessive time and presented difficulties with crooked holes and fishing jobs.[7] Similar conditions exist at Oat Mountain where fractured shale and some sands compose surface formations, and crooked hole and loss of circulation were experienced primarily above 1200 ft.[8] In both areas insufficient water is available to drill without returns. Air drilling eliminated expense of loss of circulation materials and loss of rig time suffered with conventional rotary and cable tool drilling, and in addition produced increased drilling rates on the order of 40 to more than 200 per cent, increased bit life from 36 to more than 300 per cent, and reduced drilling costs from 30 to 50 per cent. The 12¼-in. and 15-in. surface holes drilled required air volumes of 3000 to 5000 cfm at pressures of 70 to 110 psig. While drilling with air, fishing operations including washing over and side tracking, as well as setting whip stocks and directional drilling, have been accomplished without difficulty.

Geophysical Shot Hole Drilling

Air drilling has found application in drilling shot holes for seismic surveys. Conventionally, shot holes are drilled with rotary tools and water or mud for circulation to depths up to 400 ft. In remote areas water may have to be trucked long distances, and loss of circulation or drilling without returns is expensive. Air volume of 300 to 400 cfm is sufficient for drilling the 4¼-in. or 4¾-in. hole with circulating pressures ranging from 25 to 100 psig.[8] Results so far with air in shot holes have not consistently shown the economic

Air drilling operation, Oat Mountain area, California.

advantages found in other applications mentioned above. Advantages, however, may become more apparent as crews gain experience with this method of drilling.

Mechanics of Air and Gas Drilling

Experience with air and gas drilling has established that higher penetration rates and longer bit life are possible, as compared with conventional rotary hydraulic drilling. This is believed to be due to:

1. Cleaner hole bottom due to rapid removal of cuttings by extremely high velocity around the bit.
2. Absence of mud cake.
3. Low viscosity and solids content of the gaseous drilling fluid.[10]
4. The cooling effect of large volumes of expanding and highly turbulent air or gas.

Functions performed by gaseous drilling fluid are removal of cuttings and cooling of the bit. Volume of gas required for drilling is governed by the particle lifting capacity that is proportional to the density and square of the velocity of the rising gas column. Relationship between gas density, gas velocity, particle shape and particle size may be expressed as follows:

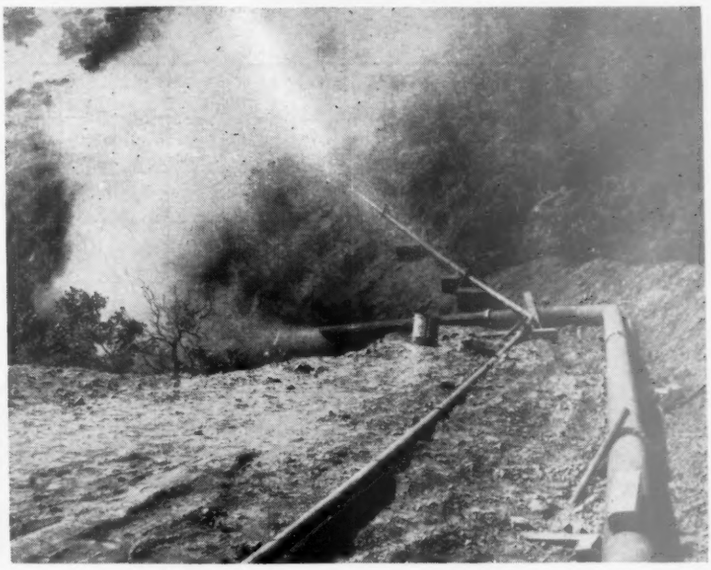
$$V = 2.67\left(\frac{d\,\rho_p}{\rho_f}\right)^{1/2}$$

This describes the slip velocity of a sphere in gas that varies considerably from the shape of rock cutting; however, in the highly turbulent velocity of the annulus, particle shape becomes less important and the few measurements taken so far indicate this to be a satisfactory criteria for the design of gas circulating systems.[9]

Air and Gas Lifting Capacity Determination

Lifting capacity determination may be made graphically by referring to Fig. 1 and 2. In order to determine the required lifting capacity, it is first necessary to find the pressure at the bottom of the hole. Fig. 1 gives a graphical solu-

Air drilling compressor hookup.



Air drilling exhaust line.

tion for bottom hole pressure for a given particle size lifting capacity, hole depth, and drill pipe diameter. Using the bottom hole pressure just determined, Fig. 2 graphically solves the gas density and velocity required to lift a given particle size at the given depth. It may be seen that lower velocities are capable of lifting smaller cuttings, and higher velocities will lift large cuttings. In practice, high lifting capacity (over ¾-in.) requires excessive power; low lifting capacity (under ⅛-in.) results in regrinding and slow penetration rates. Gas volume required to produce the above determined density and velocity may be graphically solved by reference to Fig. 3. Air volume is found knowing velocity and annular area of hole. This volume is corrected to standard conditions of temperature and pressure. If surface conditions vary appreciably from standard atmospheric conditions, additional compressor capacity must be provided to supply this quantity of gas.

Example. Assume the following: Depth of hole 4000 ft, hole size 6¼-in., drill-pipe size 3½-in., temperature at bottom hole 120 deg. Find volume of free gas required to lift ¼-in. particle.

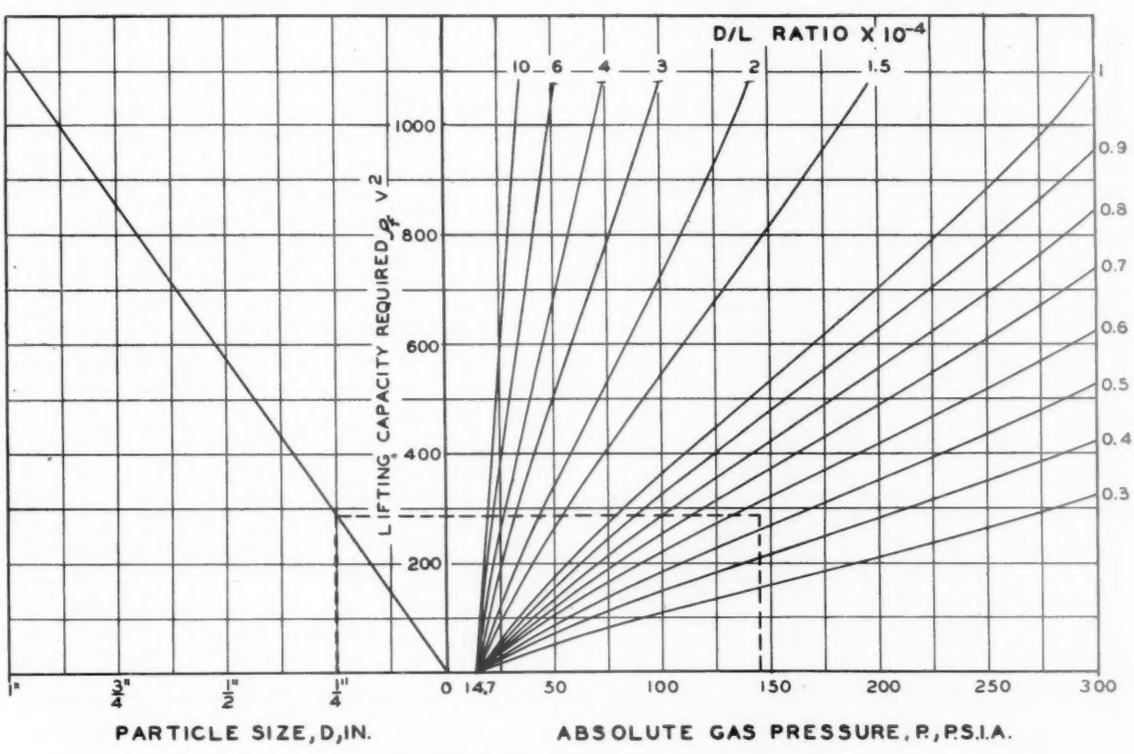


FIG. 1. BOTTOM HOLE PRESSURE DETERMINATION.

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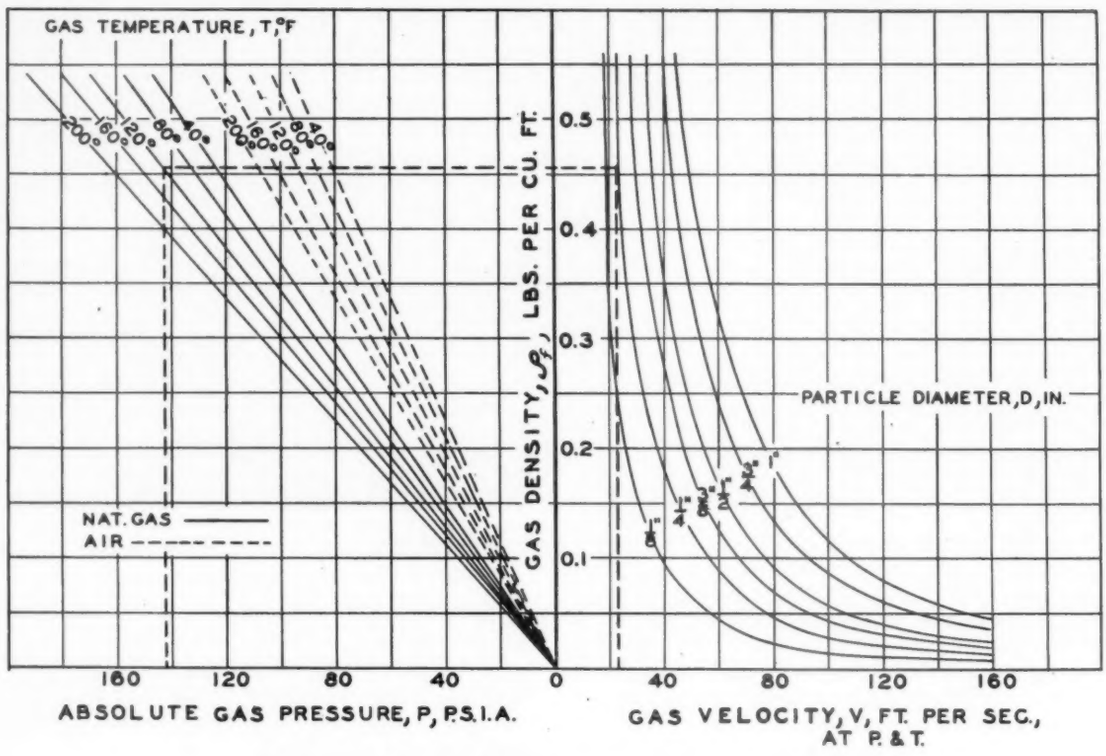


FIG. 2. GAS AND AIR LIFTING CAPACITY DETERMINATION.

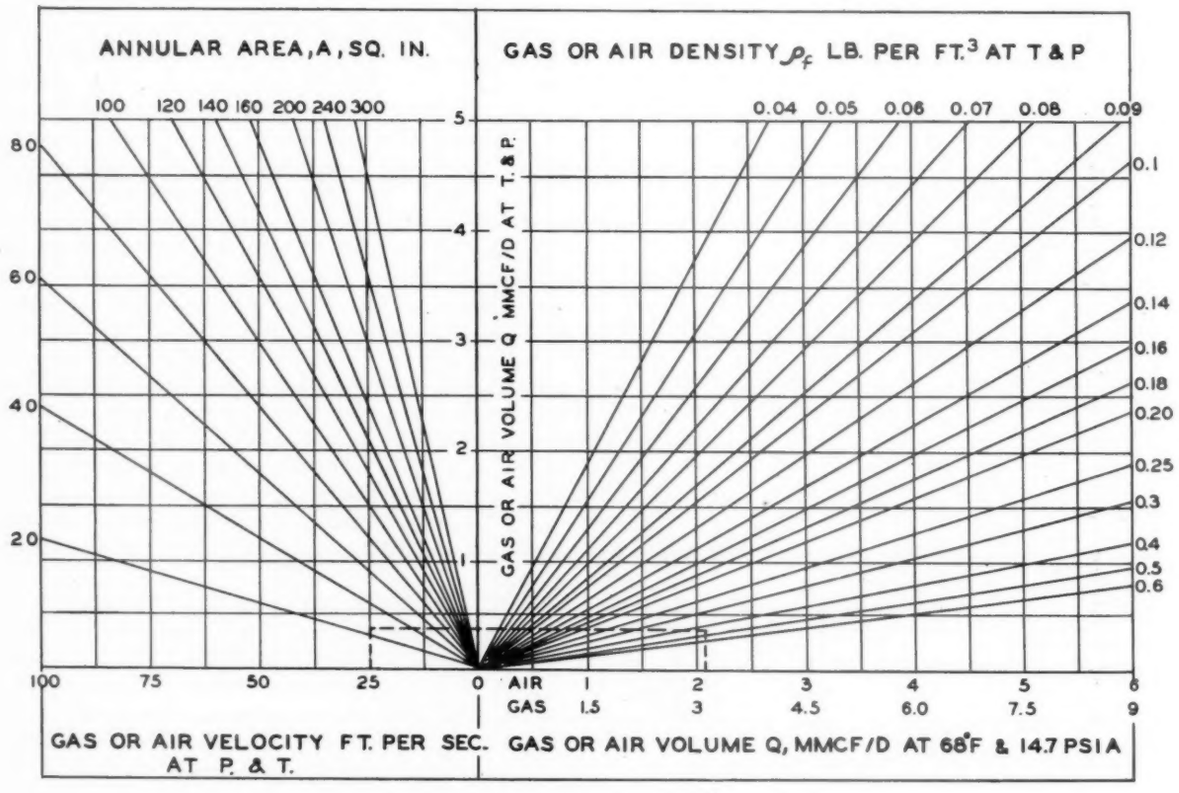


FIG. 3. GAS AND AIR VOLUME DETERMINATION

TABLE 1. Equivalent diameter to depth ratio, D/L × 10^{-4}.

Hole Dh size	4¼	6¼	10⅝	10⅝	10⅝	12¼	12¼
Pipe Dp size	2⅜	3½	3½	4½	6⅝	4½	6⅝
Depth, L							
500	3.1	4.6	11.8	10.2	6.7	12.9	9.4
1000	1.6	2.3	5.9	5.1	3.3	6.5	4.7
2000	0.79	1.2	3.0	2.6	1.7	3.2	2.3
3000	0.52	0.77	2.0	1.7	1.1	2.2	1.6
4000	0.39	0.58	1.5	1.3	0.83	1.6	1.2
5000	0.31	0.46	1.2	1.0	0.67	1.3	0.94
6000	0.26	0.38	0.98	0.85	0.56	1.1	0.78

Basis: Hydraulic radius of annulus $= \frac{(D_h - D_p)}{4}$

Equivalent diameter of the annulus, $D = D_h - D_p$

TABLE 2. Calculated free air and gas volume required for ⅜-in. particle lifting capacity.

Pipe size	2⅜	2⅜	3½	3½	4½	4½	6⅝	6⅝
Circ. fluid	Air	Gas	Air	Gas	Air	Gas	Air	Gas
Hole size	Volume mmcf per day							
4¼	0.9	1.2						
6¼			1.8	2.1				
10⅝			4.6	5.6	4.3	5.3	3.9	4.5
12¼					5.6	6.8	5.2	6.0

Step 1. Refer to Table 1 to determine the equivalent diameter to depth ratio, D/L, which for 6¼-in. hole, 3½-in. drill pipe and 4000 ft hole depth is 0.58 × 10^{-4}.

Step 2. On Fig. 1 enter chart at ¼-in. particle size, find intersection with D/L ratio of 0.58 and read bottom hole pressure of 145 psia.

Step 3. On Fig. 2 enter chart at gas pressure of 145 psia, find intersection with bottom hole temperature of 120 degrees, project to intersection with ¼-in. particle diameter. *Note:* Density of gas under these conditions of 0.46 lb per cu ft. Project vertically to read gas velociy of 25 ft per second. This is the required velocity of 0.46 lb per cu ft gas which will float a ¼-in. particle.

Step 4. To determine required compressor capacity to provide above determined amount of gas, enter Fig. 3 at gas velocity of 25 ft per second, find intersection with annual area of the 6¼-in. hole and 3½-in. drill pipe of 22 sq in., project horizontally to intersection with gas density of 0.46 lb per cu ft and read free gas volume of 3,100,000 cu ft per day at standard conditions of 68 F and 14.7 psia.

If the example were desired for air drilling, the amount of air may be determined in the same manner and read on the same air scale in Fig. 3.

Equipment for Air and Gas Drilling

Drill Pipe. Hole size and pipe size are of prime importance as the gas or air volume, and to a large degree, pressure is determined by the annular area and size of drill stem. If the drill pipe is selected as large as feasible in keeping with the fishing hazard, then gas volume requirement will be low, and the pressure drop will also be kept to a minimum. On the other hand, if small drill pipe is selected with respect to the hole, comparatively large volume of gas is required and the pressure drop will be high. Table 2 shows the calculated gas volume necessary to provide a ⅜-in. particle lifting capacity in various hole and pipe size combinations.

Drill Collars. Much of the pressure drop occurs in drill collars, and it is therefore advantageous to select large bore collars when gas or air drilling is contemplated. Table 3 shows the magnitude and distribution of pressure drop in three typical air and gas circulating systems.

Bits. Conventional roller rock bits have been used for most part in gas and air drilling operations. Circulation nozzles have been enlarged in some cases where large volumes were being circulated, although smaller nozzles have been tried in others to ascertain if jetting action is beneficial as in hydraulic drilling. Lack of conclusive results seems to indicate that there is insufficient mass in the gaseous nozzle stream to accomplish any appreciable cutting action. It, therefore, would be advantageous to keep the pressure drop across the bit low by enlarging the circulation nozzles.

Surface Piping. Pressure drop throughout the circulation system should be minimized where practical to maintain the compressor power reasonably low. Any reduction in pressure drop in the system will reduce the compressor fuel consumption or allow the circulation of larger volumes of gas. Compressor manifold, stand pipe, rotary hose and kelly should therefore be of ample size in keeping with the volume of gas or air being circulated.

Compressors. Compressor requirement is dictated by the hole and drill pipe size that determines gas volume, and the circulating system, which determines circulating pressure. In air drilled surface holes or shot holes, pressures can be maintained below 110 psig which is as high as one stage of compressors can produce. For "drilling in" two stages of compressors are necessary unless, as in the San Juan Basin field, gas is available at an adequate pressure. Table 4 shows the gas and air volumes, pressures and bottom hole conditions for several typical drilling examples.

Kelly Packer. Packing off the annulus at the surface and diverting gas and cuttings into the exhaust line has been accomplished by rotating kelly packers. Little pressure exists at this point with conventional direction circulation (less than 1 psig); however, with reverse circulation the full circulating pressure of perhaps several hundred psi is

TABLE 3. Pressure drop in typical gas and air circulating systems.

Hole size			4¼	6¼	12¼
Drill pipe size			2⅜	3½	6⅝
Depth			400	5000	1000
Circulating fluid			Air	Gas	Air
Particle size lifting capacity			¼	¼	⅜
Description	Length ft	Size in.	Pressure Drop, psi		
Surface manifold	50	1½	3.2		
	150	4		0.7	
	150	6			1.0
Standpipe	18	2	0.2		
	60	4½		0.1	
	60	4½			1.0
Rotary hose	20	1½	1.5		
	55	3		0.9	
	55	3½			4.0
Swivel		1½	1.5		
		2		1.0	
		2½			4.0
Kelly	30	1½	2.2		
	60	2¾		1.1	
	60	3½			4.5
Drill pipe	340	2⅜	13.6		
	4760	3½		210	
	840	6⅝			6.5
Drill collars	60	1½	8.3		
	240	2¼		28	
	160	3½			35
Bit			4.0	15	15
Annulus			12	160	7
Exhaust	100	4	0.6		
	300	7		0.9	
	300	10			0.8
Total pressure drop			46.1	417.7	78.8
Free gas volume mmcf per day			0.4	3.5	3.9
Theoretical adiabatic compressor horsepower			21	610	450

TABLE 4. Typical gas and air drilling conditions.

Circulating fluid	Hole size in.	Drill pipe size in.	Hole depth ft.	Circulating rate mmcfpd	Circulating pressure psig	Gas density bottom hole pcf	Gas velocity bottom hole fps	Lifting capacity bottom hole in.
Air	4½	2⅜	200	0.4	35	0.12	60	0.38
Air	6¼	3½	7000	1.5	280	0.56	16	0.12
Gas	6¼	3½	6000	3.0	405	0.60	20	0.21
Air	12¼	6⅝	800	5.0	90	0.14	57	0.39

exerted on the packer. A typical gas and air drilling riser is illustrated in Fig. 4.

Exhaust Pipe. It is important that gas and cuttings are discharged a considerable distance from the rig floor. Exhaust lines are run 300 ft more or less on down-wind side of rig, and in case of gas drilling the exhaust is flared. Size of exhaust line should be selected to provide a higher lifting capacity than in the annulus to prevent a build up of cuttings in this line.

Air and Gas Drilling Techniques

Circulation of gas or air is controlled by the stand-pipe valve on rig floor, as shown in Fig. 5. Closing this valve stops circulation and compressors automatically unload. Connections are made by stripping the kelly and single through the packer in place. When making round trips, pipe is stripped through the packer unless the well is not flowing gas, in which case the packer can be set back with the kelly. It is necessary to circulate on bottom for 5 or 10 min before starting a round trip in order to clean the hole. Even so there is a fill up of several feet of cuttings composed of larger particles traveling slowly or suspended in the hole. Only small cuttings travel near gas velocity, where larger cuttings float until reground to lifting size and then move up the hole. There is little danger of these cuttings sticking the pipe as they become quite fluid when circulating gas. It is possible to circulate the bit through cuttings without rotation.

Loss of circulation reduces the velocity in the annulus, and there is a reduction in the size of cuttings in the returns. Low pressure in the annulus prevents loss of circulation with gas or air from being serious. Sloughing hole, however, can stop gas or air drilling. Symptoms are a reduction in size of return particle and increased amount of fill in. The enlarged hole reduces gas velocity and hence lifting capacity. It is doubtful that means can be devised for combatting sloughing hole.

Weight on bit is commonly increased with gas or air circulation and rotary speed reduced. This can be accomplished as there is some evidence of less tendency to make crooked holes with gas drilling than with hydraulic drilling.[11] The appearance of the exhaust is indictive of several conditions. Returns are seen within seconds after circulation is begun; dust in the exhaust indicates cuttings are being lifted and an abrupt stoppage of dust indicates moisture in the hole.

TABLE 5. Comparison of conventional vs reverse circulation.

Hole size in.	Depth ft	Drill pipe size in.	Particle size in.	Circulation direction	Circulating fluid	Flow rate mmcfpd	Compressor horsepower
6¼	5000	3½	¼	Conventional	Gas	3.5	610
6¼	5000	3½	¼	Reverse	Gas	0.8	60
12¼	1000	6⅝	⅜	Conventional	Air	3.9	450
12¼	1000	6⅝	⅜	Reverse	Air	1.3	72

Reverse circulation has been tried on several occasions with varied results. This method can not be used in loss of circulation formation as the full circulating pressure is exerted on the annulus. It has, however, been successful for "drilling in" where increased lifting capacity was desired.[5] Reverse circulation provides the same lifting capacity with reduced volume and pressure, or a higher lifting capacity with the same quantity of gas as with conventional circulation. Table 5 shows the quantity of circulating gas and compressor power required to provide equivalent lifting capacity in two hole and pipe size combinations with both conventional and reverse circulation.

Operations other than drilling have been successfully accomplished with gas or air for circulation. Fishing jobs, including washing over and side tracking, have been conducted; directional drilling, including milling windows in casing and setting whip stocks, has been executed; and casing has been run and cemented without difficulty. Coring has also been accomplished with good results.

Fire Hazard

The few fires experienced on gas drilling operations have not occurred while drilling, but rather when the pipe was out of the hole or while running tubing, and these fires have been traced to carelessness or forgetfulness in use of

FIG. 4. GAS DRILLING RISER.

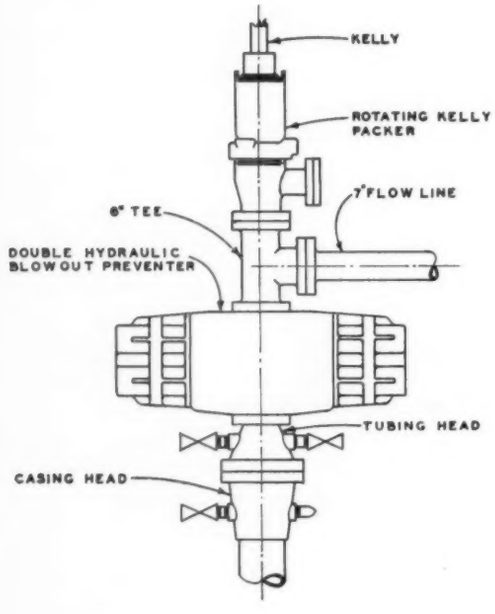
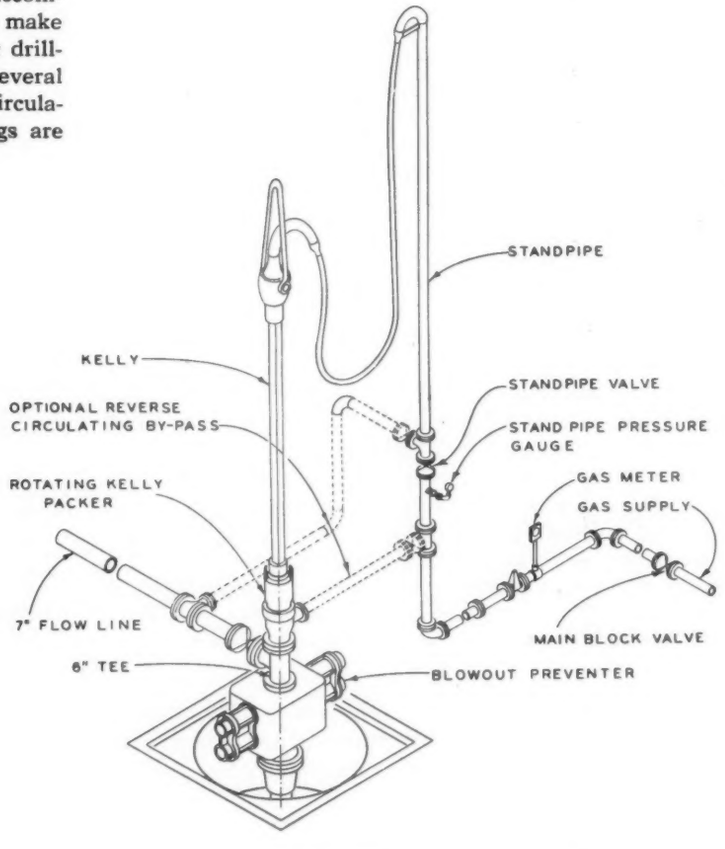


FIG. 5. GAS DRILLING HOOKUP.



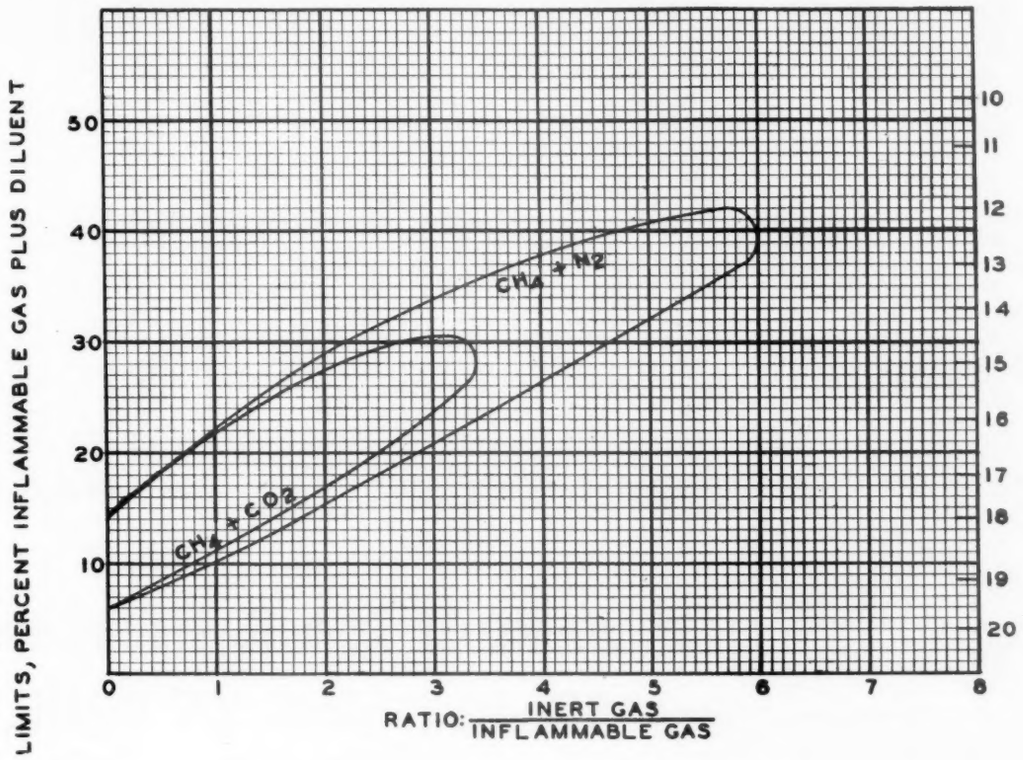


FIG. 6. LIMITS OF INFLAMMABILITY OF METHANE WHEN MIXED WITH VARIOUS PROPORTIONS OF AIR, NITROGEN AND CARBON DIOXIDE.

matches on the part of the drilling crews.[12] Precautions ordinarily taken on gas drilling operations are: Checking the piping for leaks; installation of adequate blowout preventers; use of a 300 ft flow line; injection of water in the engine exhaust; provision of adequate fire fighting equipment; provision of proper electrical systems, and education of the drilling crews.

Possibility of using air to "drill in" to gas producing zones has been given some thought. It is possible to mix sufficient inert gas with air to preclude an explosive mixture. Fig 6 shows the limits of inflammability of methane when mixed with various proportions of air and nitrogen or carbon dioxide.[13] It can be seen that if the per cent of oxygen in the mixture is kept below 12 per cent there can be no explosive mixture.

Conclusions:

Gas and air drilling methods have been shown to have the following advantages over rotary hydraulic methods:

1. Less possibility of damaging formations by drilling fluid and particle penetration.
2. Less susceptibility to loss of circulation.
3. Less tendency to contaminate cores and cutting samples.
4. Less possibility of overlooking productive formations.
5. Higher rates of penetration.
6. Longer bit life.

Major disadvantages of rotary pneumatic drilling are:

1. Apparent inability to cope with formation water.
2. Less support for sloughing formations.
3. Less control of formation pressures.
4. Higher fire hazard.

According to present day concepts gas and air drilling has economic application where formations do not tend to slough nor contain appreciable amounts of water, and one or more of the following conditions exist:

1. Producing formations are susceptible to injury from drilling fluid or particle penetration.
2. Severe loss of circulation exists.
3. Drilling fluid is expensive or non-available.

Gas and air drilling has been successfully utilized in the San Juan Basin of New Mexico and the Spraberry field of West Texas to prevent damage to the formation from drilling fluid and particle penetration. Air drilling has been successful in combating loss of circulation coupled with inadequate or expensive water supply, for drilling surface holes in the South Mountain and Oat Mountain fields in California, and for shot hole drilling in geophysical work.

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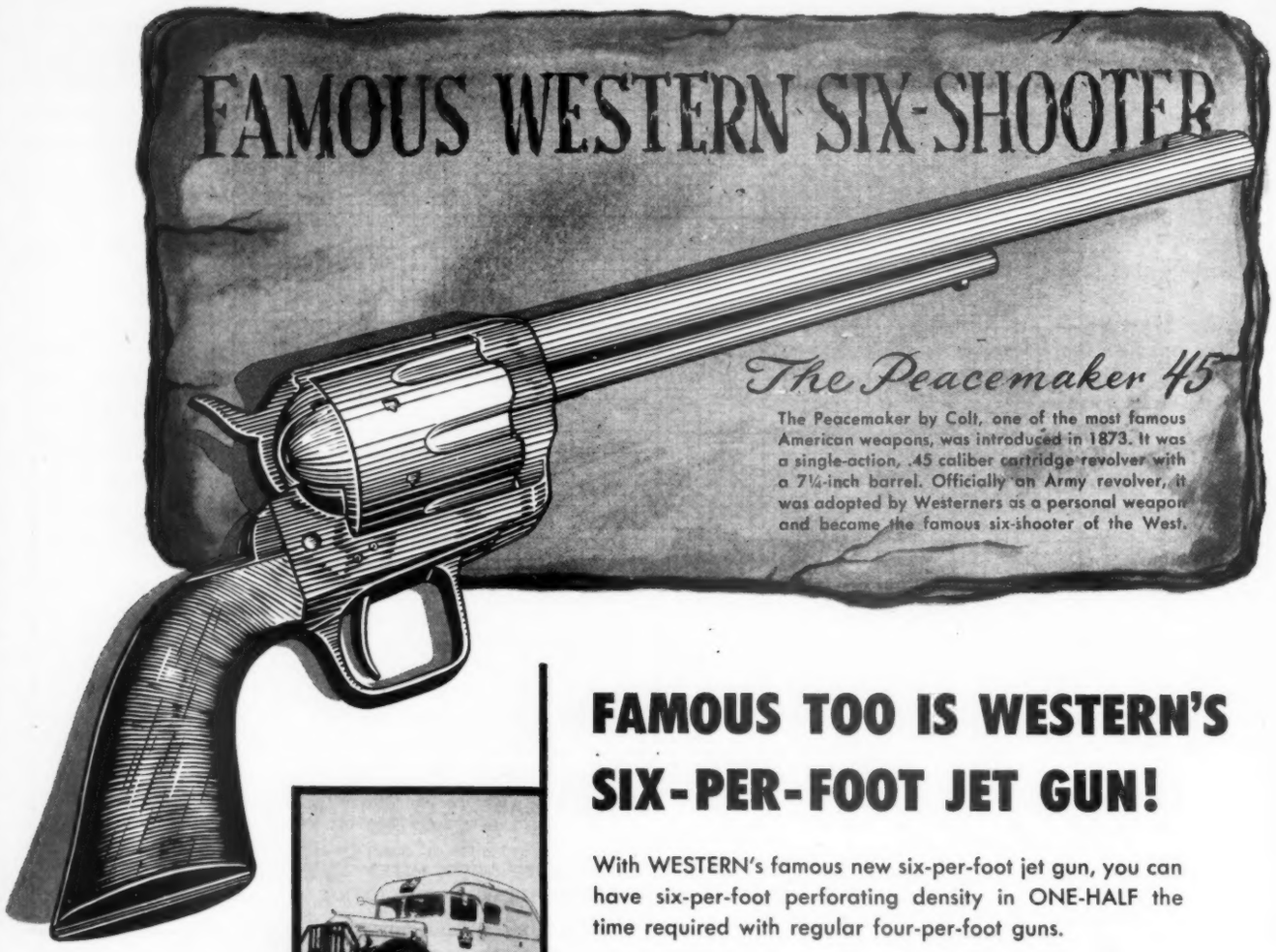
XUM

FAMOUS WESTERN SIX-SHOOTER



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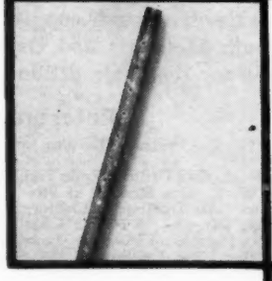

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DRAW WORKS

R. E. Kirberger*

THE old adage, "Necessity is the mother of invention," is one that holds true in the rotary drilling business. Better methods of drilling a hole in the ground have been foremost in the minds of oil men since a railroad conductor named Drake drilled a well 69½ ft deep in 1859. Little did these rugged pioneers realize that their make-shift of a hickory pole, some rope and hand-forged tools were the forerunner of a modern rotary drilling rig, capable of drilling a hole four or more miles deep.

The draw works is the pulse of a drilling rig as it provides the rotating and hoisting action of drilling a well. Although there are hundreds of companion items necessary to make a complete drilling rig, the draw works has retained its importance as it is the "name factor" of all rigs. Ask a contractor or owner what kind of a rig he has, and he will name the model and manufacturer of the draw works.

The early day (1859 to 1900) method of drilling a well with cable tools was modernized by the development of a machine that would rotate drill pipe, on the end of which was attached a bit, and drill a hole in the ground much like you would drill a hole in wood or a piece of steel. It was necessary to remove the cuttings so pumps were used to circulate fluid down the drill pipe. The returning fluid then would force the cuttings back to ground level on the outside of the drill pipe. This basic principle is still used today.

Early day draw works were operated by steam. Many of the parts were cast iron due to the accessibility of this metal. It was soon learned, however, that use of this metal was limited. A steam engine drove the hoist and rotary table by means of large exposed chains. Clutches were jaw or positive and unless extreme care was exerted by the driller when a clutch was engaged, something would break.

Demand for rotary drilling equipment that could be easily and quickly removed was born at the turn of the century and has been responsible for the modern day well engineered draw works.

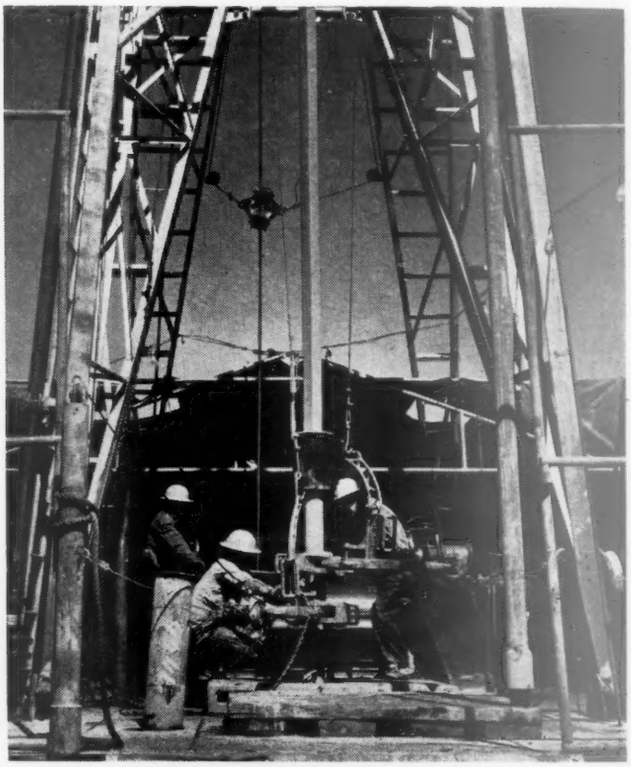
There are many factors to be considered in the design of drilling equipment such as road laws, bridges, quick set up and tear down time, ease of operation, extreme weather conditions, ease of repair and maintenance, etc. Modern engineers have accepted this challenge and conquered it by designing two basic types of draw works. One design is equipped with a pump drive and is ordinarily the larger and heavier of the two types. The other design is commonly known as a split rig. On this type the mud pump is independently driven; the draw works is simply a hoist and also a means of driving the rotary table.

Power for rigs may be supplied by diesel engines, gas engines, steam, or electric power. Design of a draw works is based upon the power requirement of the pumps. The pump requirement is based upon the maximum depth of the hole to be drilled. Consequently, a draw works with a pump drive incorporated in its design has, ordinarily, a surplus of power to do the hoisting.

In the larger draw works with incorporated pump drive,

*Service Drilling Company, Tulsa, Oklahoma.

SPRING POLE METHOD OF KICKING DOWN A WELL.



ADDING ON A JOINT OF DRILL PIPE.

the power section is constructed to accommodate two or more engines. Each engine is mounted in such a way that it can easily be removed and thus reduce the weight for moving the rig or repair of the engine. The power of each engine is discharged into a compound which permits the power from all engines to be utilized to motivate the hoisting, rotating, and pumping action of the rig. The compound is ordinarily designed so that the total horsepower or torque of all engines is synchronized through individual chain drives. Up to 2000 hp may be applied in this manner through the use of four to eight engines if necessary.

Synchronization of engine revolutions per minute in a multiple engine hook-up is important and sometimes difficult. Spark plug engines may be synchronized by simply connecting the intake manifold of each engine with a copper tube or hose. This equalizes the vacuum of all engines and thus regulates the ultimate amount of fuel sucked into each cylinder. This vacuum system cannot be used on diesel engines as the fuel oil is injected and atomized, under pressure, directly into the cylinders. Therefore, in order to synchronize a multiple diesel engine hook-up it is necessary to have precision movement of the throttle rods and linkage to the fuel pump on each engine. This problem has accelerated the use of fluid couplings and torque converters on draw works in the past several years. Due to the slippage through fluid couplings, an engine may be lagging behind, but the power from that engine will be contributed to the total output instead of being pulled by the other engines.

The pump drive is ordinarily located on the back of the compound or power section of a rig. It consists of a large sheave with grooves for V belts or is sometimes a large sprocket for chain driven mud pumps. It is equipped with adequate chain and clutch capacity to receive the full power output of all engines. Quite often on the larger rigs it is necessary to have two pumps. The horsepower requirement for two large pumps on one rig may be as high as 600 hp for each pump.

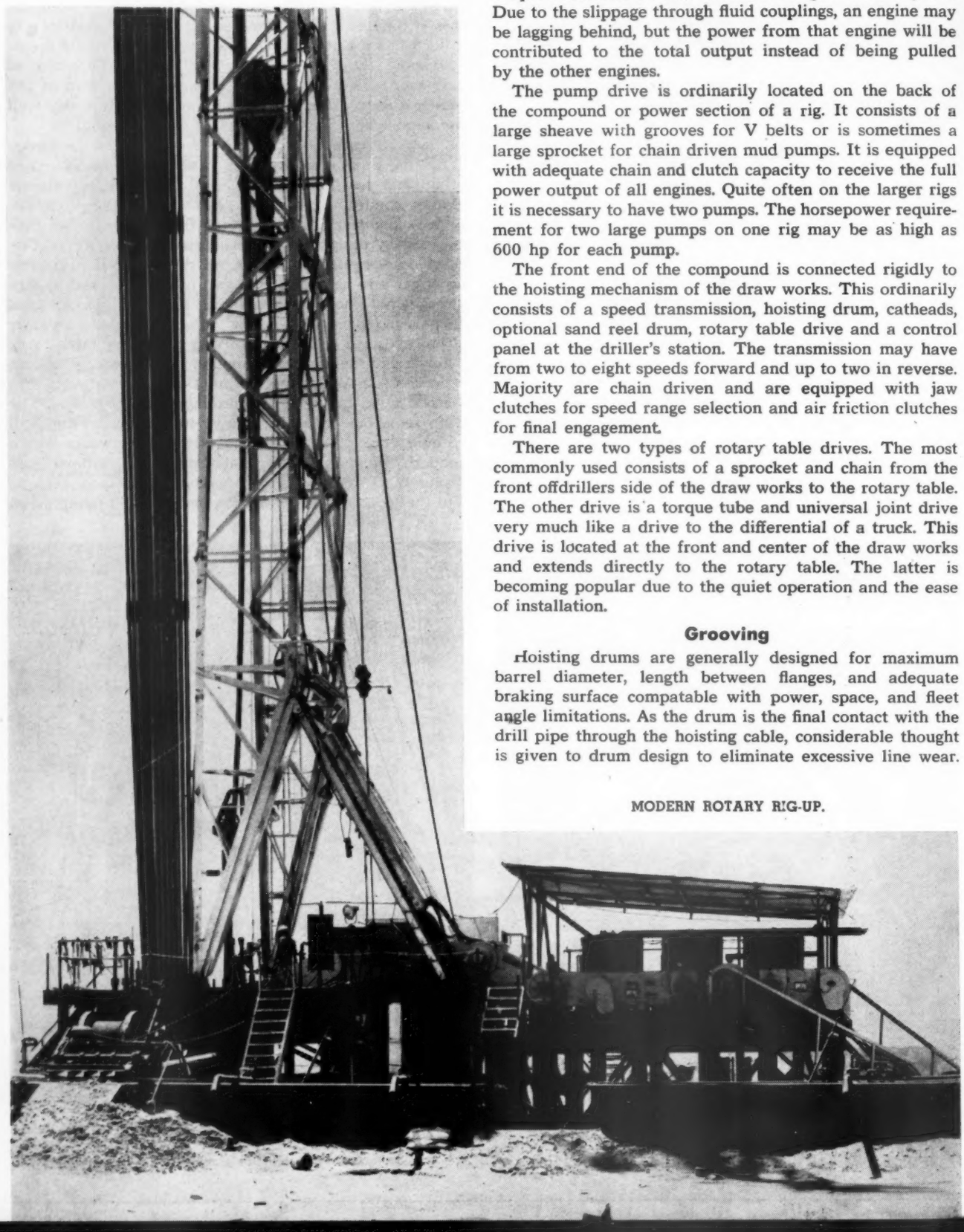
The front end of the compound is connected rigidly to the hoisting mechanism of the draw works. This ordinarily consists of a speed transmission, hoisting drum, catheads, optional sand reel drum, rotary table drive and a control panel at the driller's station. The transmission may have from two to eight speeds forward and up to two in reverse. Majority are chain driven and are equipped with jaw clutches for speed range selection and air friction clutches for final engagement.

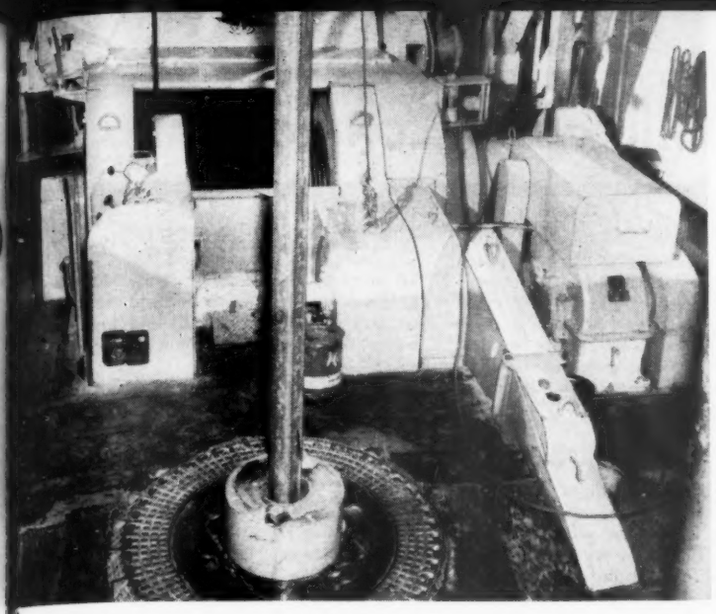
There are two types of rotary table drives. The most commonly used consists of a sprocket and chain from the front offdrillers side of the draw works to the rotary table. The other drive is a torque tube and universal joint drive very much like a drive to the differential of a truck. This drive is located at the front and center of the draw works and extends directly to the rotary table. The latter is becoming popular due to the quiet operation and the ease of installation.

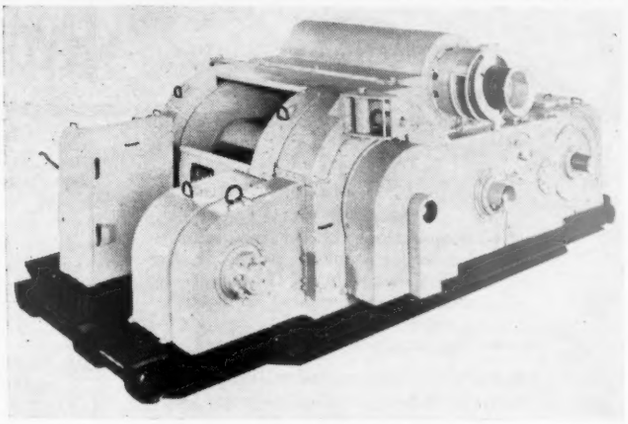
Grooving

Hoisting drums are generally designed for maximum barrel diameter, length between flanges, and adequate braking surface compatable with power, space, and fleet angle limitations. As the drum is the final contact with the drill pipe through the hoisting cable, considerable thought is given to drum design to eliminate excessive line wear.

MODERN ROTARY RIG-UP.







Left, Floor view of a present rotary drilling rig.
Above, one type draw works.

Most manufacturers endeavor to minimize line cross over by designing the drum as large in diameter and as long between flanges as possible. It is very important that each wrap of line lay as close to the preceding wrap as possible. Some manufacturers machine a spiral groove on the drum barrel to act as a guide. Others have a spiral grooved jacket that is bolted on to the barrel. Also available is a grooving that is welded to the drum in segments and directs the line to wrap in a pyramid fashion. It is said the latter will permit more layers of line with less chop through.

Catheads

In the drilling of wells it is necessary to replace bits and this is done by pulling the drill pipe out of the hole and unscrewing the pipe and standing it in the derrick. Due to a flat shoulder on the drill pipe joint, it is necessary to exert considerable force to unscrew the tool joint. This is done by means of a cathead. Here is an operation that has been greatly improved from an efficiency and safety standpoint. Catheading was done by simply wrapping a rope around a revolving cathead and through friction the force or pull of the rope is exerted to the desired operation. This type of catheading is extremely hazardous and should always be done by an expert.

Modern catheads have eliminated approximately 95 per cent of the manual catheading. There are ordinarily two types of catheads on a draw works. One is known as a breakout that is used to unscrew the drill pipe as it is pulled out of the hole. The other is known as a spinning and make-up cathead that is used to screw together and tighten the drill pipe joints as it is lowered back into the hole. Both of these catheads are mechanical and are operated by conveniently located controls at the driller's station.

Hydromatic and Dynamatic Brakes

The cycle of pulling the drill pipe out of the hole, standing the pipe back in the derrick, installing a new bit on the drill pipe and going back in the hole is commonly known as making a trip. This operation is as interesting to watch as any athletic contest as a good crew is a well coordinated team. Each man has a definite operation to perform and deviation will delay getting the bit back on bottom. An efficient crew will make a trip look so easy it will be difficult to realize they are working with hundreds of tons of weight in the deeper wells.

In order for a trip to be made quickly and safely, it is necessary for a draw works to have a good brake. Therefore, a great deal of thought has been given to the brake rims, bands, and lining on the draw works drum. Most drums are cooled by circulating water through a water jacket in each brake rim. This will minimize the heat generated by the terrific friction of the drum and the asbestos brake lining on the band. The abrasive action of this friction, however, soon wears out both brake rims and lining so engineers have designed a hydromatic brake and/or a dynamatic brake to assist the mechanical brake.

The hydromatic brake is designed very much like a centrifugal pump. It is driven directly by a high speed roller chain from the drum or is attached by a flexible coupling to the live drum shaft. There are various means of automatically metering the amount of water permitted to pass through the hydromatic brake, thus assisting the mechanical draw works brake in retarding the descent of the drill pipe into the hole. The dynamatic brake is applied to the draw works in exactly the same manner. The dynamatic brake is basically two opposed magnetic fields and the energy generated by the brake is converted into heat, which in turn is dissipated in the cooling water flowing through the brake.

Although neither of these assist brakes will actually stop the drill pipe descent, they will effect a snubbing action that will necessitate the friction brake to stop and hold the full load only.

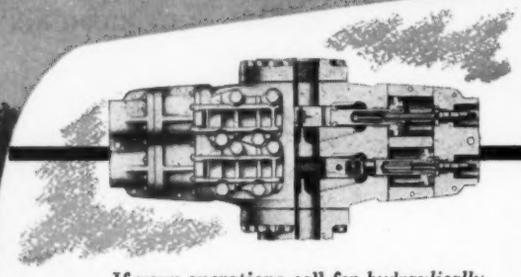
Automatic Feed Devices

When the drill pipe is in the hole and drilling is commenced, care must be exerted by the driller to regulate the amount of weight imposed on the rotating bit. If the weight of the full string of drill pipe is imposed on the bit, it is very likely the drill pipe will twist off some place in the string and an expensive fishing job will be necessary. There are many reasons why the proper amount of bit weight should be carried at all times. Here again is an important function of the draw works brakes.

In recent years there have been a number of devices designed to adapt to a draw works drum for the purpose of feeding off a predetermined weight to the bit. The device is attached to the draw works drum in about the same manner as the hydromatic or dynamatic brake. These devices are automatically controlled so that constant bit weight will be maintained regardless of the type of formation being drilled and whether or not the bit is dull or sharp. It is said that the device will drill faster, drill a straighter hole and will eliminate many fishing jobs by replacing the human element that is necessary to maintain constant bit action by observation and feel.

There are hundreds of new ideas being developed to better the drilling of oil and gas wells and it will be interesting to look back on the year 1954 just like we are looking back on the first make-shift rig that successfully drilled the Drake well in 1859.

XUM



Hydraulic CELLAR CONTROL GATES

If your operations call for *hydraulically*-operated cellar control gates, Shaffer Hydraulic Cellar Control Gates are—by all standards—unsurpassed in dependability, compactness and years-ahead operating features.

In addition, Shaffer Hydraulic Gates are available in both *Double* and *Single* types—whichever you prefer. Both incorporate the same advanced features, and parts are, in most cases, interchangeable between the two types, simplifying inventory and maintenance. Both types feature...

SIDE DOOR RAM CHANGES: To change rams, simply unbolt doors in the side of the Gate, change rams and bolt the doors shut again. It's by far the quickest, simplest method of changing rams—and in Double Gates, rams in the upper and lower compartments can be changed with equal simplicity. There's no need to dismantle the upper compartment to change rams in the lower compartment—or vice versa. Each compartment has its own doors—is equally accessible!

TRUE COMPACTNESS: There's no need to expand the length of Shaffer Gates—or leave extra room above them—in order to change rams. The doors open across the minimum dimension where there's plenty of room for convenient ram changes. Even in sizes as large as 13⅜" (12" Series 900) Double Gates require a total height of only 30"—Single Gates only 18½"—overall (smaller sizes even less). Length and width dimensions are comparably compact!

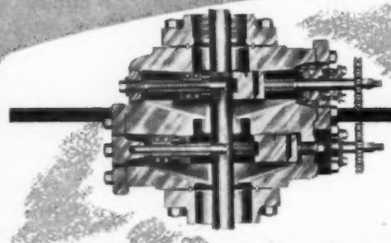
COMPLETELY ENCLOSED DESIGN: No moving parts are exposed in Shaffer Gates—all are completely protected within the gate body. Nothing to become damaged or jammed by objects falling into the cellar, or corroded by chemical muds.

DIRECT HYDRAULIC DRIVE: Shaffer operating cyclinders are *directly behind* the rams. For maximum safety there are no secondary connections or yokes between hydraulic cylinders and rams!

AND REMEMBER THIS IMPORTANT FACT... with Shaffer Hydraulic Gates you don't have to choose between one type for compactness—another type for maximum pressure protection. *The same basic Shaffer design combines BOTH maximum compactness and maximum pressure protection*—one more vital Shaffer advantage!

These are only a few of many Shaffer advancements. Be sure to get ALL the facts from your Shaffer representative — or write direct!

You have this important choice only from SHAFFER!



Mechanical CELLAR CONTROL GATES

Where *mechanically*-operated cellar control gates are desired, Shaffer not only has the most advanced equipment of this type—but also provides a choice of *Double* and *Single* types. Both types incorporate such exclusive features as these...

UNUSUAL COMPACTNESS: The Shaffer *Double* Gate (*two* gates unitized into *one* body) requires *less than 29"* of cellar height, even in sizes as large as 13⅜" (12" Series 900). The 13⅜" *Single* Gate requires only 17⅜" of cellar height. Smaller sizes in both types are even more compact!

SIMPLE RAM CHANGES: Only one end cover need be removed to completely change a set of Shaffer rams—and in Double Gates, each compartment is equally accessible without interfering with the other.

EFFECTIVE POWER DRIVES: Shaffer Mechanical Cellar Control Gates can be effectively operated by Shaffer Air Motor Drives which utilize the air supply available at the rig. They require only minimum air at moderate pressure—and are direct reversing so that they may be used for either closing or opening the gates. Single Air Motor Drives are used to operate Shaffer Mechanical *Single* Gates and Dual Air Motor Drives for Shaffer Mechanical *Double* Gates.

INTERCHANGEABLE RAMS: Ram Blocks and Ram Rubbers for Shaffer Mechanical Gates are interchangeable, size for size, with those used in Shaffer Hydraulic Gates. Where both types of gates are used, this advantage greatly simplifies ram maintenance and cuts inventory costs.

For all the facts on the many advantages built into Shaffer Mechanical Cellar Control Gates, see your Shaffer representative. Or write direct!

Get an unbiased recommendation

on the type of control gate best suited to your operations. Since Shaffer — and only Shaffer — is a leader in both *hydraulic* and *mechanical* gates, Shaffer alone can provide you with the type of operation best suited to your *particular* needs. Your Shaffer representative will gladly give an unbiased recommendation!

The Shaffer Section of your Composite Catalog has helpful data on Shaffer equipment. Or send for your free copy of the latest Shaffer catalog.

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XUM

SLIPS AND POWER SLIPS

R. A. Malott*

WHEN rotary drilling came into use, a dual problem was posed. The rotary table had to provide both a way to apply drilling motion to the pipe and a method of supporting the pipe when going in or pulling out of the hole. This was solved in 1912 by the invention of the kelly, kelly drive bushing and the master bushing.

Master Bushing Design

The master bushing is designed with a square opening in the top to provide driving contact with the square on the kelly bushing. A conical bowl below this opening is provided for slips which support the pipe. These wedge-shaped slips are machined to fit the taper of the master bushing bore and have dies of hardened teeth to grip the pipe.

Unitized Hand Slips

In the beginning, these slips were handled in two or three segments by the rotary helpers or roughnecks, but as drilling progressed deeper and longer strings of pipe were used, it was necessary to set slips on the same level to prevent putting a bending moment in the pipe. Unitized slips were the solution. Three slip segments were hinged together and three handles provided for simultaneous handling by the crew. Length of the slips was also increased to provide greater contact area with the pipe and thus minimize the tendency to crush the pipe while gripping. Master bushing design was also improved. Non-split models, not dependent on the rotary table recess to maintain their inside dimensions, are being used on long heavy strings of pipe. Some of these bushings are hinged with a latch while others are solid.

Power Slips Introduced

Hand slips require the crew to pull the slips manually as each section or stand of pipe is added while going in the hole, and as each stand of pipe is racked while coming out. This involves not only considerable work and added crew fatigue but also certain hazards of crew members. To relieve this hard hand work and reduce the costly accident factor, power slips were first introduced in 1942. As with all prototype designs, these initial power slips had shortcomings. They were difficult to put into service, consumed too much space, interfered with rig floor operation, and involved a high maintenance cost. Some models restricted clearance through the master bushing. In a few cases, there was an indication that introduction of power slips interfered with the timing of the drilling crew to the point where the driller miscounted the number of singles in a stand or pulled too high and hit the crown, but this difficulty was overcome by the use of crown warning devices.

*Shell Oil Company.

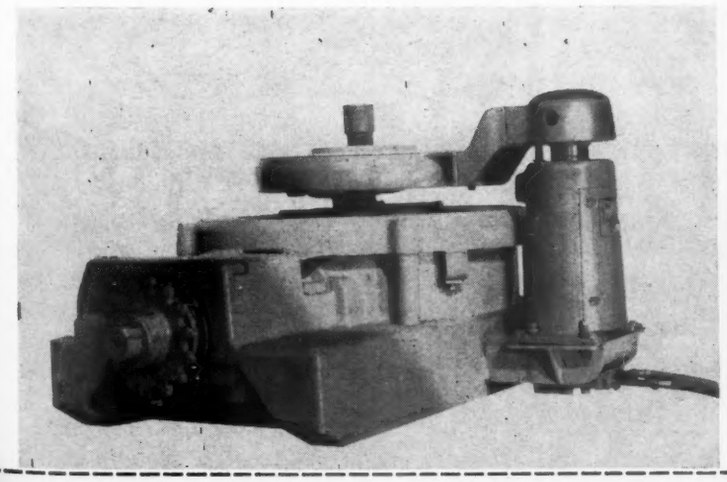
Power Slips Modernized

Improved power slips have overcome these original objections. These mount directly to the rotary table and are transported as a unit with the table. Speed of operation is adjustable and unitized slip construction is provided. Important safety features are built into some modern power slips. One prevents slips from setting in event of air line failure. Another guards the slips from damage by the elevator if the driller accidentally runs the elevator into the raised slips. This safety feature is accomplished through a relief valve which automatically sets the slips when the elevator contacts the slip arm ring. This latter feature also protects the drill string in accidents caused by running into the crown block or by drilling line or other equipment failure. If the drill string falls under these accidental conditions, the raised slips automatically set upon contact with the falling elevator, thus catching and holding the pipe and saving a costly fishing job. The high maintenance factor which penalized early power slips designs has also been corrected. Most modern power slips are rugged enough to stand up under normal rig operation with a minimum of service attention.

Expanded Use of Power Slips

In addition to drill pipe handling, power slips accommodate tubing sizes by using smaller slip inserts. A recent development which broadens the capacity of at least one make of power slips is the casing bowl. This bowl fits in place of the master bushing and extends the use of the slips to casing sizes up to 13⅜ in. Another interesting development is that some of the new rotary tables are now designed by the manufacturer to include power slips which are integrated with the table. With a growing trend toward power methods and a current recognition of economies and safety gained through power tools, the indication is that old style hand slips may eventually disappear from the drilling scene.

Power slip model and the same type in use on a drilling rig.



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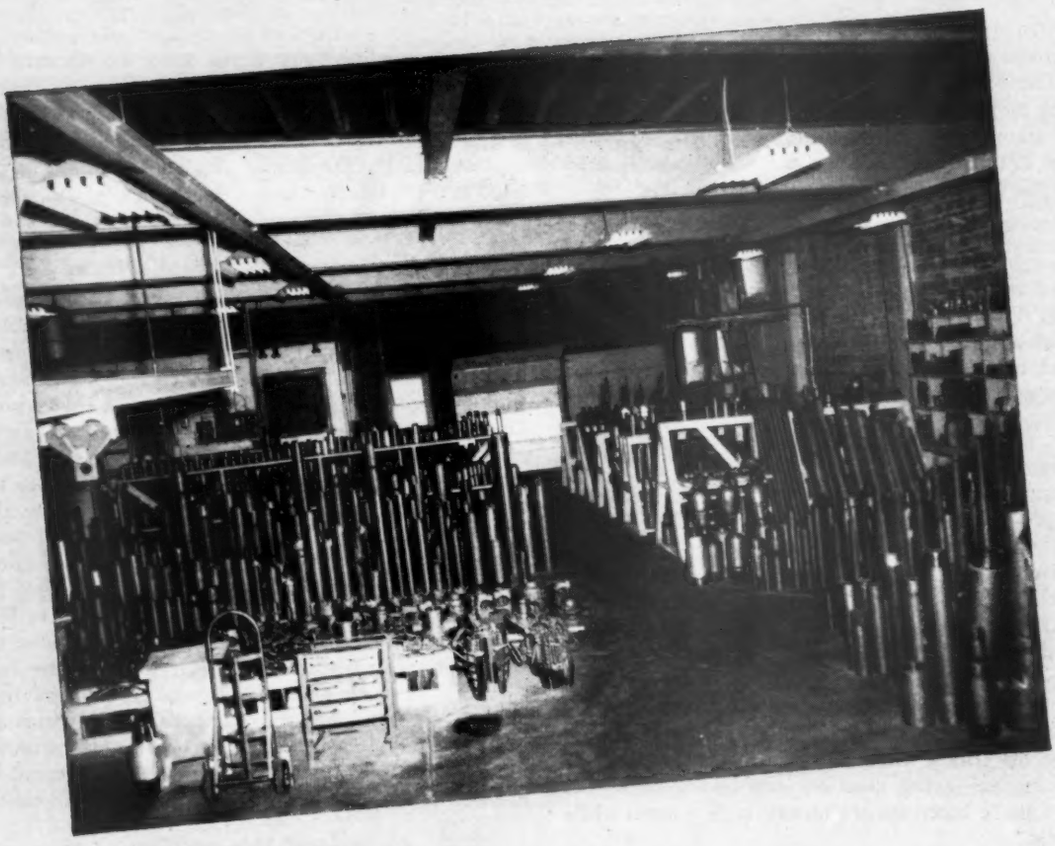

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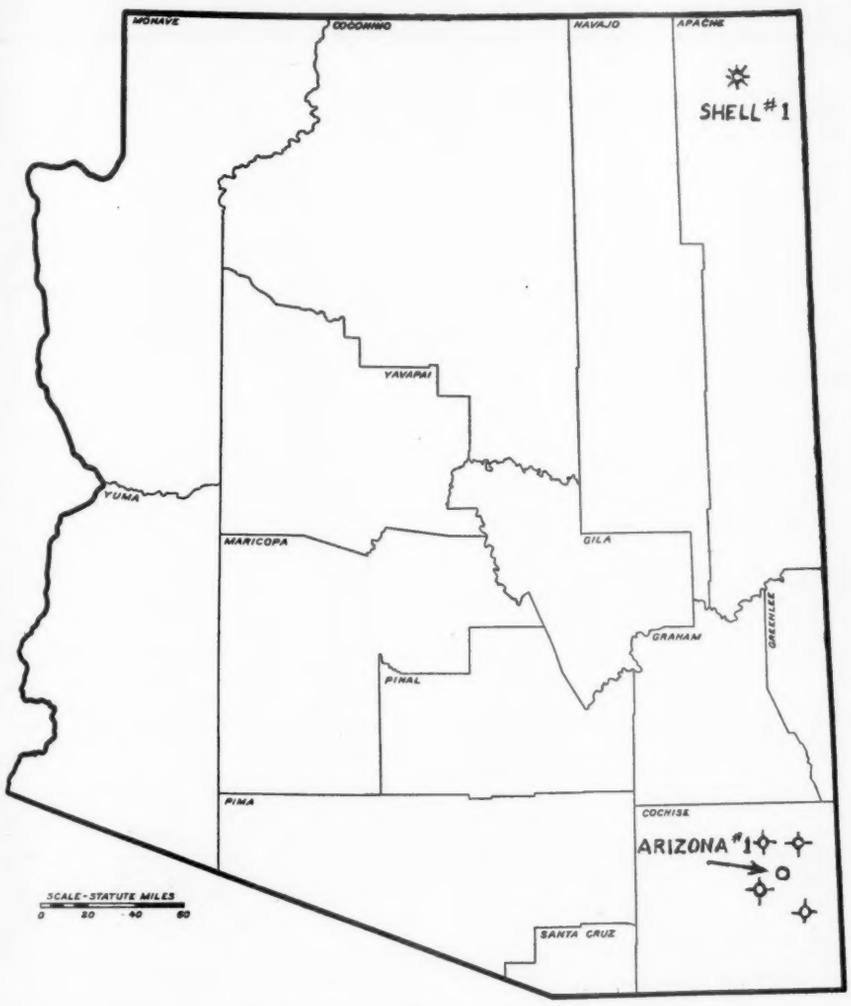

FIG. 1. Map of Arizona showing Shell's Navajo No. 1 and site of new wildcat.

Wildcat in Arizona

Drilling operations begin on what may be state's second producer

PREPARATIONS have begun on a 7500-ft oil and gas test well in Southeastern Arizona, eight miles south of San Simon. The well, Arizona No. 1, (Fig. 1) will be drilled as a tight hole. Several wells drilled in the area have had good shows of oil and gas and extensive geological research and magnetometization was made of the area. Every horizon will be tested in what is believed to be a promising structure. Eugene Talbot and Ed Finley of Tyler, Texas, will use a 10,000-ft rotary rig in drilling the test.

Sam R. Kaufman of Tucson, Arizona, assembled the lease block of 15,000 acres where Arizona No. 1 will be drilled. Meyer Nathan of Dallas and Tyler, Texas, Bernard Wolf, and A. D. Clark of Tyler were associated with Kaufman in arranging for the test.

Shell Oil's Navajo No. 1 (Fig. 1) is located due north of Northeastern Arizona on a 22,577-acre lease in the Navajo reservation. Shell first estimated a daily output of 2,000,000 cu ft, which increased to 3,000,000 when developmental work was completed. The Navajo No. 1 is the state's first natural gas producer. * * *

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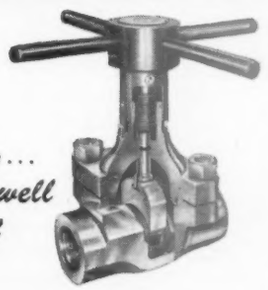

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To obtain more information on products advertised see page E-61

XUM

OKLAHOMA

★ Magnolia Petroleum Company has extended the West Marlow field of Stephens County, Oklahoma, ½ mile to the northwest at its No. 1 Rourk, which is producing from two sand zones.

With casing perforated in Cisco sand at 5226-38 and 5458-88 ft, the well flowed 425 bbl of oil per day, with gas-oil ratio of 7270-1, through 16/64-in. choke. From the Coline sand at 5756-93 ft, the well tested 200 bbl of oil, with gas-oil ratio of 25,310-1, per day through a ½-in. choke.

★ Superior Oil Company No. 2 Reeves, Garvin County, total depth 9036 ft, flowed 252 bbl of new oil in 24 hours through a ¾-in. choke. The 34-deg oil flowed from perforations 8932-64 in Springer with 50 lb tubing pressure.

★ The Carter Oil Company No. 2 Schaffer Heirs, Noble County, total depth 5070 ft, has been completed for a flow rate of 240 bbl of oil per day. The flow was through a 14/64-in. choke from Misener sand 4696 to 5012 ft with gas-oil ratio of 2009-1. Casing pressure was 1500 lb and tubing pressure was 1000 lb. Oil was 44.1 deg.

★ Amerada Petroleum Corporation No. 2 Daugherty, Garvin County, fractured Hart sand perforations and flowed load oil and 1400 bbl per day of new oil through a ¾-in. choke with gas-oil ratio of 1550-1. After perforating Springer sand from 9652 to 9700 ft, the well flowed 900 bbl per day through a ¾-in. choke, gravity 38 deg.

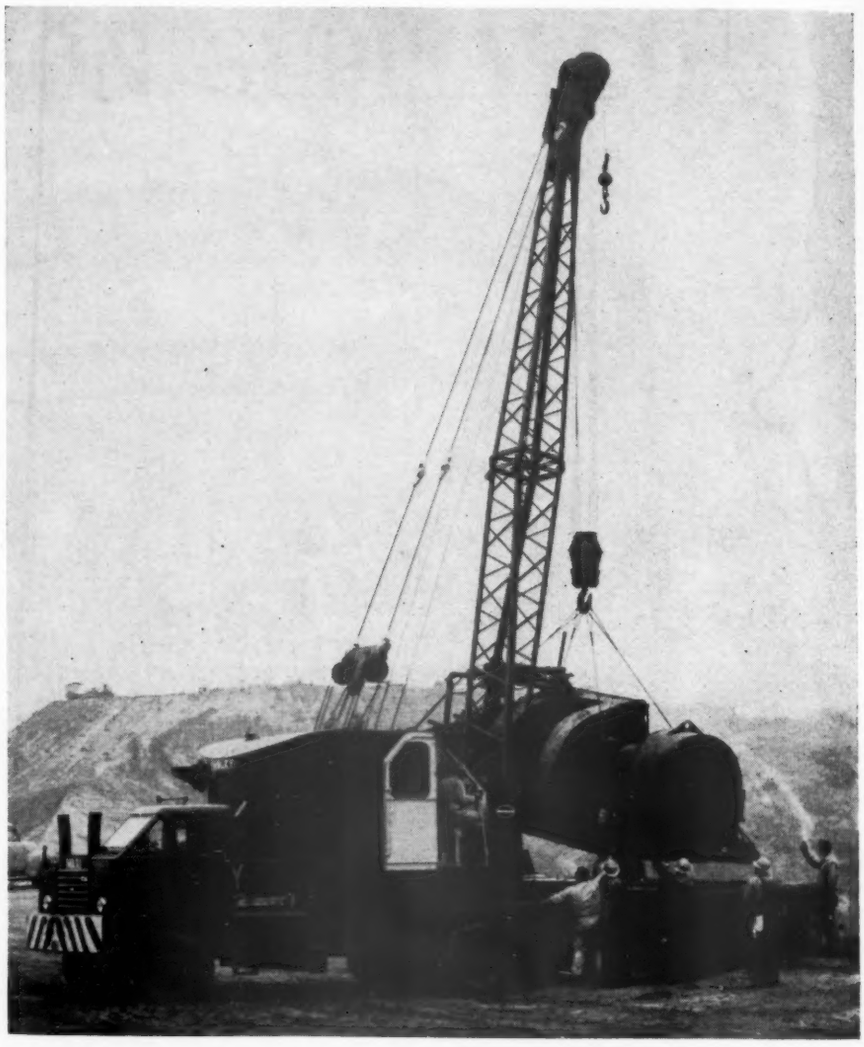
★ On the East edge of the Elk City unit, Washita County, Tide Water Associated's No. 2 Cleo Walter "B" section 19-10-21, flowed 304 bbl through a 5/32-in. choke from perforations 10, 142-10, 154 ft.

★ Greer and Abbott have extended the Ramsey pool, Payne County, one-half mile to the south, with their No. 1 Longan, pumping 100 bbl of oil a day from perforations at 4487-96 ft in the Bartlesville.

MONTANA

★ Shell Oil Company No. 41-4 NP, Cabin Creek Unit of Fallon County has recovered substantial amounts of oil through tests of the Madison. Location is ½ mile south of production limits and is drilling ahead after test of the interval 7357-7420. Tool was open four hours and yielded oil and water at a relatively high rate.

★ Shell's No. 43-9A, southeastern extension of the Pine field, Wibaux County, has been completed with a flow of 276 bbl of oil per day, from Stony Mountain perforations, 8892-8952 ft, and Red River perforations, 9031-9101 ft.



Insley Type WB truck mounted crane shown loading 6400-lb drawworks near Ventura, California, for movement to new location.

FLORIDA

★ Gulf Oil Corporation's recent oil discovery in Dade County, 37 miles west of Miami, has been completed for a daily producing rate of about 70 bbl of 20 deg oil and about 400 bbl of salt water. Gulf's No. 1 State of Florida, lease 340, was completed in the Sunniland zone below 11,340 ft from about 8 ft of net effective pay.

ARKANSAS

★ Benedum-Trees Oil Company has completed the 1 Caldwell and Lowe, a 2½-mile extension to Kiblah field, Lafayette County. The well flowed 192 bbl of 47 deg oil per day through ⅜-in. choke. Perforations were 6006-14 and 6020-30 ft in the Mitchell sand. Well is 8⅝ miles southwest of Bradley near the Louisiana line.

★ Benedum-Trees Oil Company completed 1 Caldwell and Lowe, Lafayette County, to extend the Kiblah field two and one-half miles east-northeast out of Miller County. The well flowed at the rate of 192 bbl per day, 47 deg oil, on ⅜-in. choke, from perforations at 6006-14 and 6020-30 ft in the Mitchell sand of the Rodessa. Gas-oil ratio was 800-1.

MICHIGAN

★ A 1-mile northwest extension of the Northville Trenton field, Washtenaw County, is seen in the Edward Torosian No. 1 Nerreter, Salem Township. Test in the Trenton at 4221 ft showed 400,000 cu ft of gas a day on initial gage. Trenton was topped at 4095 ft. First showing of gas was at 4198 ft and an increase was reported at 4212 ft.

four most desired features

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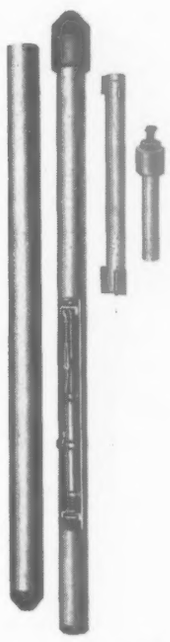
Decreases jarring and pulling to release packer, minimizes drag going in hole, reduces number of misruns in oversized holes, leaves less rubber to be drilled out.



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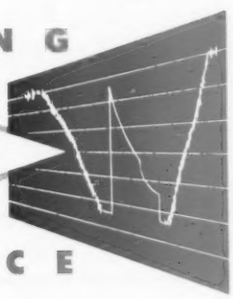

HALLIBURTON'S BEST FOR YOUR DRILL STEM TEST

LOUISIANA

★ Completion of Union Producing Company No. 5-A Continental has extended production in the Kent Bayou field of Terrebonne Parish a mile to the southwest. From casing perforations 11,131-11,133, well flowed at a rate of 227 bbl of 37.1 deg oil per day through a 7/64-in. choke. Flowing tubing pressure was 2200 lb with the gas-oil ratio 1040-1.

★ M. H. Marr has opened a new producing horizon, at Phoenix Lake, Calcasieu Parish, at his No. 1 Odom. The sand is producing through perforations 9780-92 ft. The well flowed 173 bbl of 37.5 deg gravity oil per day through 8/64-in. choke under pressure of 1500 lb, with gas-oil ratio of 202 to 1. TD was 11,550 ft.

★ Buffalo Oil Company, Dallas, has a new wet gas field in Lafayette Parish at No. 1 Mary McConnell. It produced 50 bbl of distillate per day through 18/64-in. choke along with 3,578,000 ft of gas. Pay is from 9940-50 ft.

★ Southern Natural has established a new oil sand in the No. 1 Perry in the Franklin field of St. Mary Parish. Producing through casing perforations from 10,209-12, well was gaged at 186 bbl per day with a gas oil ratio of 1059-1 while flowing through a 12/64-in. choke.

★ Two new oil pay horizons were established on the east side of the old Black Bayou field in Cameron Parish.

The dual find was at John W. Mecom No. 1 W. E. Lea. From the Marginulina sand at 7950-66 ft it gaged 479 bbl per day through 12/64-in. choke with tubing pressure 600 lb. Gage from Discorbis sand at 7152-62 was 456 bbl daily through 3/16-in. choke with tubing pressure 1325 lb.

★ Union Producing Co. 1 Antrim, Webster Parish, extended the South Sarepta field two and one-half miles east-southeast. The well was completed flowing 66 bbl of 65.3 deg condensate and 1,003,000 cu ft of gas per day through 12/64-in. choke from perforations at 9653-60 ft in the Davis. Gas-oil ratio is 15,197:1.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	April 12	April 19	April 26	May 3	May 10	May 17
Pacific Coast	140	136	141	140	142	146
Oklahoma	382	378	366	356	352	315
Kansas	155	158	153	163	164	164
Rocky Mountains	240	247	261	254	248	252
Canada	152	146	141	127	112	112
Ark-La-Tex	192	186	186	191	173	169
West Texas and New Mexico	490	496	486	483	482	463
Gulf Coast	562	571	569	566	561	563
Illinois	122	113	142	126	130	142
North Texas	314	321	316	322	331	304
	2749	2752	2761	2728	2695	2630

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

TEXAS

★ Skelly Oil Company is completing the second well on its block of 11,000 acres in Webb County, near Laredo, where its No. 1 J. C. Martin opened the Aquilares pool. Skelly set 5½-in. casing to total depth of 6960 ft to complete the No. 1 J. O. Walker.

Four different producing sections were encountered. They are at 6093-6117 ft, 6220-50 ft, 6723-33 ft, and 6875-6900 ft, for a total of 89 ft of gas-distillate pay. The well ran considerably higher than the discovery well.

The No. 1 J. C. Martin was dually completed through perforations at 6125-48 ft and at 6255-76 ft, for a combined potential from the two zones of 13,000,000 cu ft of gas per day with 8 bbl of distillate per million.

★ Husky Oil Company, Cody, Wyoming, has completed its No. 1 Cowden Ellenberger well in the Emma field, Andrews County, Texas. The well flowed 453 bbl of 49.6 gravity oil through a ½-in. choke in five hours. It is rated as having a production potential in excess of 2000 bbl per day.

The well was drilled to a total depth of 12,570 ft, somewhat short of the base of the Ellenberger formation. It is the highest well structurally drilled in the field to date.

Rig is moving 1320 ft due south from the completion and will start drilling operations immediately on a second Ellenberger well.

★ Tidewater has completed No. 1 and 2 Barnsley in the Lea field, Crane County, from the Connell and Ellenburger formations. Allowables for each pay section are 180 bbl per day. On potential test, No. 1 flowed 251 bbl through a ¼-in. choke from the Connell zone, from perforations 8194-8204 ft, and 381 bbl through a 5/32-in. choke from the Ellenberger zone, from perforations 8310-8347 ft. Similar rates of flow were obtained from the No. 2 Barnsley well.

★ Seaboard No. 5-A Billie Hanks, Hylton Northwest field of Nolan County, 7 miles northeast of Blackwell, has logged good shows in the Cambrian.

Core from 5926-74 ft recovered 43 ft of lime bleeding oil, 5 ft of coarse grained Cambrian sand with good odor and show of oil. Core from 5974-89 recovered 15 ft of Cambrian sand, which had a good odor and oil saturation throughout. Top of the Cambrian was 5969 ft.

Drillstem test from 5969-89 surfaced gas in 5, mud in 16, and oil in 18 min. After cleaning 20 min it was tested through ⅜-in. top choke with flowing pressure of 215 lb and produced 23.8 bbl of oil per hour. Oil tested 50.6 gravity and GOR was 523-1.

NORTH DAKOTA

★ Two important completions by Amerada Petroleum Corporation in North Dakota are announced. One is the No. 1 Erickson in Mountrail County, producing 393 bbl of oil per day. This well is three-fourths of a mile east of the East Tioga discovery.

The other completed well is Amerada's No. 1 Koheen Unit, gaged at 500 bbl per day, in an extension of the Beaver Lodge pool in Williams County.

COMING

Development of Well Logging and Quantative Log Analysis in Kansas (Part 1)
Louis G. Chombart

Secondary Recovery in the El Dorado Field (Part 3)
E. E. Funk and W. M. Cantrell

Vertical Drive, a Correlative Force in Oil Production
Ralph Spearow

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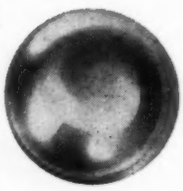

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Drilling

NEW MEXICO

★ In New Mexico, Tide Water Associated completed No. 3 Anderson, Lea County. It flowed 893 bbl a day through a ¾-in. choke from perforations 5210-5235 ft in the Paddock sand.

★ Aztec Oil and Gas Company is now operating independently of its former owner, Southern Union Gas Company. Southern Union divested itself of all ownership interest earlier this year. Aztec, however, was operated by the parent company under an interim service agreement until May 1.

The new Aztec Oil and Gas Company deals principally with the production and sale of gas and oil. Aztec properties, all in New Mexico, include more than 50,000 acres of producing oil and gas leases, with interests in nine oil wells, nearly 200 gas wells and around 70,000 acres of leases.

Southern Union will continue to acquire, explore and develop oil and gas leases and has budgeted in excess of $3,000,000 for such purposes in 1954.

★ Active development by Cities Service of its 3500-acre drilling block in the Drickey field of Chavez County, New Mexico, is underway. The company has two drilling rigs on the block, and expects to add several more immediately.

Cities Service already has completed its Government B No. 1 and B No. 2 wells for initials of 300 bbl each. Production is from the Queen sandstone at approximately 3000 ft.

The Drickey field is in southeastern New Mexico, approximately 30 miles northwest of Lovington and five miles southwest of the Caprock field.

KANSAS

★ Flowing Pennsylvanian oil production is indicated at Stanolind Oil and Gas Company No. 1 U.S.A. "C," an oil well in Greenwood gas field, Morton County.

Formation tops are the Lansing at 2957 ft, upper Morrow at 4192 ft, Keyes sand at 4458 ft, and lower Morrow at 4472 ft. Perforations are in the Purdy sand at 4210-16 ft (Upper Morrow).

★ Bishop Oil Company has announced its Henderson No. 2, Pratt County, has been completed to production. It is the second well on the property. Two other producers previously have been drilled by Bishop on the adjoining lease.

Henderson No. 2 has been given daily allowable of 34 bbl. The Kansas Corporation Commission calculated its initial potential at 832 bbl daily, on the basis of an 8-hour test.

Total depth was 4400 ft. The well was perforated and hydrafraced from 4298 to 4312 ft in the Simpson sand. Oil is 37 deg.

AAODC SAFETY CLINIC

★ The 9th Annual Drilling Safety Clinic of the AAODC was held May 13-14 at the Baker Hotel in Dallas, Texas. National President K. L. Kellogg, of Compton, California, delivered the opening address. He stated that safety is a matter of understanding, attitude, and effort, and has found that this can be only enlisted through a cooperative program. The annual clinic was attended by about 200.

CALIFORNIA

★ A trend toward deeper drilling is observed by Standwood I. Williams, president of Thomas P. Pike Drilling Company. He reports that six out of the 14 company rigs now operating in California oil fields are currently drilling below 10,000 ft. Demand for the company's special deep drilling equipment continues to develop as exploration discovers new sands at lower levels, often below old fields and depleted petroleum reservoirs. Operations of company rigs are reported as follows:

★ Tide Water Associated Oil Company has complted three oil wells in its Ventura Avenue field, near Ventura, California.

Flowing 580 bbl of 33.2 gravity oil and 335,000 cu ft of net gas daily on compressor, McGonigle No. 35, the new well, is using a 40/64-in. bean and producing from a depth of 12,190 to 13,000 ft in the lower D-7 zone.

V. L. & W. No. 100 is flowing 366 bbl of 33.8 gravity oil and 462,000 cu ft of gas daily through a 28/64-in. bean from the D-5 and D-6 zones at a depth of 10,450 to 11,377 ft.

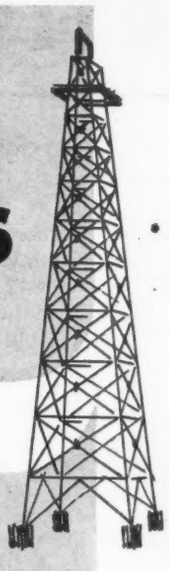
Lloyd No. 176, which is producing 492 bbl of 32.8 gravity oil daily, is also producing 123,000 cu ft of gas through a 30/64-in. bean. The gas and oil are coming from a depth of 11,022 to 12,180 ft in the D-8 zone.

★ Union Oil Company announced its fourth successful completion in the North Guijarral Hills producing area in Fresno County, California, when Whittmore 6-26 came in flowing 38 deg crude oil at an initial rate of 1500 bbl per day with 560 psi tubing pressure. Two adidtional wells, are nearing completion and the quality of oil sands already penetrated give every indication they will be high volume producers.

COLORADO

★ An apparent Colorado discovery about 2 miles west of production at Padroni in Logan County, is Claycomb, Guida and New Drilling Company No. 1 Kelly. A test of the "J" sand interval 4828-66 ft recovered 870 ft of free oil and 60 ft of water-cut mud. Flowing pressure was 80-150 psi. Casing has been landed and the operators are completing for final testing.

OIL WELLS



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Box 1926, Casper, Wyo.
Room 1404, City Nat'l Bank Bldg., Houston, Texas

EXPLORATION ACTIVITIES

OKLAHOMA

★ Discovery of a new western Oklahoma gas field was announced by The Texas Company when the wildcat L. J. Barby "A" Well No. 1, Section 2, Township 4 North, Range 25 East, Beaver County, Oklahoma, flowed at the daily rate of 2,500,000 cu ft of gas on a one hour drillstem test.

One hundred feet of distillate was reported in the drill pipe. Perforations were made at 6740-6761 ft in the Morrow Pennsylvania sand, and bottom hole pressure was 2000 lb.

The L. J. Barby No. 1 is five and half miles southwest of the nearest production, the Northwest Knowles Pool. It is eight miles west of Knowles, Oklahoma.

LOUISIANA

★ Union Oil Company has reported a significant oil discovery on the east bank of the Mississippi River, 45 miles north of New Orleans. The well is on the Richbend prospect in St. James Parish.

The discovery well, Karstien No. 1, came in flowing clean 39 deg gravity crude oil at a rate of 175 bbl a day through a ⅛-in. choke with 2200 lb flowing pressure.

NEW MEXICO

★ Warren Petroleum Company and Jake Hammon No. 1 Federal-Davis, in Lea County, appears assured as a prolific Devonian producer. Test from 12,090-12,120 ft yielded oil at a 14 bbl per hour rate with flow improving.

★ Stanolind et al No. 1 State of New Mexico AD was completed in the Pennsylvanian for an estimated 4,000,000 cu ft of gas per day. The well is located in Eddy County, about 20 miles northeast of Carlsbad. Drilled to a total depth of 13,260 ft to test the Ellenburger, the wildcat was plugged back to 11,091 ft in the Pennsylvanian.

TEXAS

★ Husky Oil Company, Cody, Wyoming, announced that it has completed its No. 1 Cowden Ellenberger well in the Emma field, Andrews County, Texas. The well flowed 453 bbl of 49.6 gravity oil through ½-in. choke in 5 hours. It is rated as having a production potential in excess of 2000 bbl per day.

The well was drilled to a total depth of 12,570 ft, somewhat short of the base of the Ellenberger formation. It is reported to be the highest well structurally of those drilled in the field to date. In announcing the completion, Husky announced also that it is moving the rig 1320 ft due south from the site of the completion and will start drilling operations immediately on a second Ellenberger well.

★ American Gas Production Company No. 1 Silsbee "A" one and one-half mile northwest extension Southeast Camrick field, flowed 26,600 Mcf of gas per day through open tubing from the Morrow sand at 6674-86 ft.

★ A new oil discovery in Aransas Bay on State Tract No. 258, Nueces County, Texas, has been announced by Sunray Oil Corporation and Seaboard Oil Corporation.

The new wildcat well was tested in the Upper Frio sand from 7786 to 7796 ft at the rate of 219 bbl per day of 41 gravity oil and 360,000,000 cu ft of gas. Gas-oil ratio is 1643:1. The wildcat was drilled to a total depth of 9540 ft. Several additional sands were located, the sidewall cores indicating possibility of oil or gas production in other zones which will be further tested.

★ The Texas Company announced the extension of the northwest flank of a new oil field in Ector County, West Texas, upon the recovery of 54 bbl of 40.5 gravity oil in three hours on a drillstem test of The Texas Company No. 1-B TXL, Section 9, Block 45, Township 1 north, T. and P. Survey.

Gas was surfaced in eight minutes from the 7930 to 8011 ft section of the wildcat well, which is located three-quarters of a mile northwest of the No. 1-J Cummins, discovery well.

★ Sterling Oil, Tulsa, has a 5000 ft Ellenberger test scheduled for immediate drilling on a lease of 320 acres on the W. T. Waggoner estate ranch. Operation is known as the W. T. Waggoner A-1, with location being in the H&TCRR Survey, Wilbarger County, 15 miles south of Vernon.

The lease is located on a seismic high with a north offset producing from Ellenberger. Previously developed production is to the southeast of the Sterling venture.

★ Seaboard No. 1 Tillman, Midland County, has been completed as a flowing Strawn producer. Well tested at a 160 bbl per day rate on ¼-in. choke after treatment of the section through perforations 10,450-10,510 with 5000 gal of acid.

MEXICO

★ Texas International Sulphur Company is core drilling for sulphur in the Isthmus of Tehauntepec, Veracruz, Mexico. A truck mounted rig has been drilling at points in a 123,550-acre concession where surface geology indicates salt structure.

WYOMING

★ Pacific Western Oil has a discovery at its No. 1 Prescott-State, 18 miles northeast of Thermopolis, in Washakie County. With casing perforated at 4752 to 4842 and 4862-92 and at 4962-5012 ft, in the Tensleep, the wildcat swabbed 410 bbl of oil in its first 24 hours.

COLORADO

★ Virgil O. King, Denver, and James F. Smith, of Amarillo, have a discovery in the Denver Julesburg basin of Washington County, Colorado, at their No. 1 Windolph, 13 miles west of Akron townsite.

On drillstem test of the "D" sand at 4834-54 ft, the wildcat showed an estimated 4,500,000 cu ft of wet gas a day; recovery was 150 ft of clean oil and 150 ft of oil-cut fresh water.

UTAH

★ Boundary Butte, a 3-state geologic feature, with gas proved in the New Mexico and Arizona corners, is promised a deep wildcat in the Utah area. Ohio Oil Company announced the staking of No. 1 Navajo, San Juan County, southeastern Utah, with work to get under way shortly for a 7000-ft test to the granite.

KANSAS

★ Kansas City lime oil shows were reported in Midstates Oil Corporation et al No. 1 Ravenstein, one-half mile southeast stepout to the Davis pool. Drillstem test recovery from 3545-65 ft in the K. C. lime was 300 ft of oil and gas-cut mud. A test at 4076-98 ft recovered 140 ft of gas-cut mud from the Mississippian.

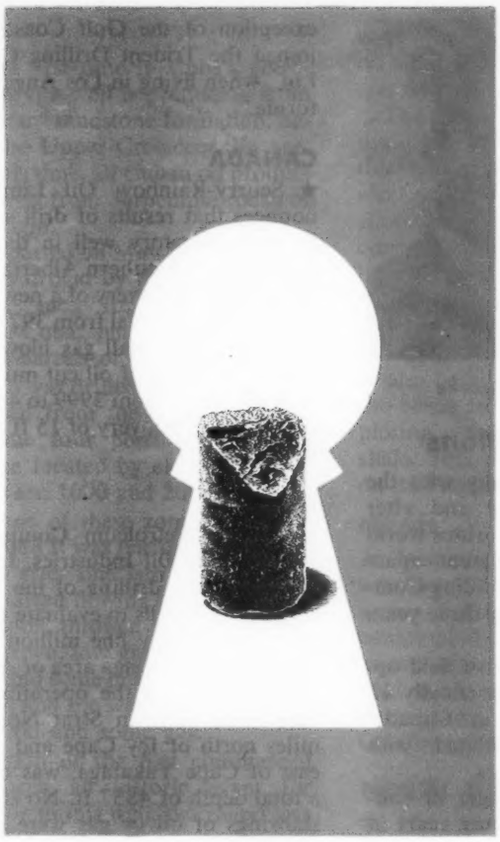
★ A three-eighths mile step-out to the northeast of the Chesney Dome in the El Dorado field of Butler County, Kansas, is reported in a test at Cities Service Chesney No. 38.

In a 15-hour test of 2 ft of the 17 ft of Simpson sandstone from 2522 to 2524 ft, the well swabbed at the rate of 192 bbl of oil daily.

CALIFORNIA

★ Gilliland Oil Company et al has a new pool discovery in the Degany Gap area, Kern County, northwest of Devils Den production in SW SE 3-25s-18e. Operators have completed No. 1 Miller for a daily average production of 100 bbl of clean oil 23 deg.

Standard of California had good shows in a deep test east of Oxnard in Ventura County. The No. 1 Lucas is flowing by heads and operator is preparing to install pump. Well was drilled to 10,570 ft.



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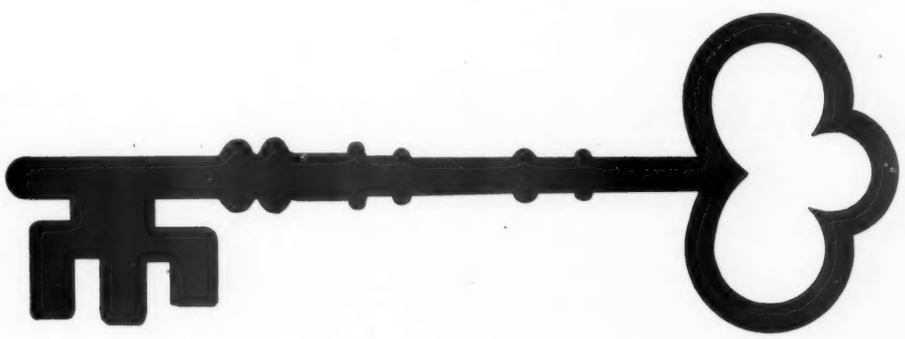

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Trident general offices are in Calgary at 803-8 Street West. Field office and yard are in Edmonton at 11220 76 Avenue.

E. E. Moore, vice president and general manager, was originally with the Arrow Drilling Company and after many years of service, in various world oil fields, and in several different capacities, formed the Trident Drilling Company, Ltd., in Alberta some three years ago.

O. O. Coshow, manager of field operations, has worked in practically all of the oil fields in the USA and Canada. Coshow has been associated with Moore for the past six years.

Ed. M. Gearke is manager of contracts. He has operated many years in several different capacities for the Baash-Ross Tool Company. He has worked the Rocky Mountain area, Canada, and the Mid-Continent with the exception of the Gulf Coast. Gearke joined the Trident Drilling Company, Ltd., when living in Los Angeles, California.

CANADA

★ Scurry-Rainbow Oil Limited announces that results of drill stem tests of its exploratory well in the Badger Lake area of Southern Alberta indicate the possible discovery of a new oil field. A test of the interval from 3975 to 3995 ft produced a small gas blow and recovery of 130 ft of oil cut mud and 90 ft of oil. A test from 3999 to 4011 ft resulted in the recovery of 15 ft of oil cut mud.

ALASKA

★ Phillips Petroleum Company and Kerr-McGee Oil Industries, Inc., have completed the drilling of the first of a series of test wells to evaluate the block of approximately one million acres in the Katalla-Yakataga area of Alaska on which they hold the operating rights. This well, Sullivan Strat No. 1, is 4 miles north of Icy Cape and 26 miles east of Cape Yakataga, was drilled to a total depth of 4837 ft. No significant showings of oil or gas were encountered, and the well was plugged. The second well, Sullivan No. 1, will be drilled at a location five miles west and two miles north of the original test well.

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CUBA

★ For the first time in Cuba's petroleum history, a well is producing from a sedimentary sandstone formation, believed to be Upper Cretaceous in age. Prior to this time, all Cuban oil production has been from Serpentine rocks of ignious origin.

First reported on May 2, this wildcat which was drilled by the Kerr-McGee Industries, Inc., for the Jarahueca Group in Cuba, has been producing about five barrels of oil per hour.

The well was drilled to 8375 ft, using a rig leased from the Cuban government. Some four possible producing zones were located by electric log, all lying between 1000 and 2000 ft.

From one of these zones, a section 1072 to 1088 ft was perforated with 64 shots and after one run of the swab, the well started flowing about five barrels per hour, through a ⅝-in. choke, making brown, low gravity oil, quite a bit of gas and some mud. The mud soon cleared up and the well is now producing clean oil and some gas.

Production of the first commercial oil has been an historic event for Cuba. Prior to this well, the island was largely dependent upon imported crude from Venezuela to operate the 1000 bbl-a-day refinery at Cabaiguan in Las Villas Province. This refinery is about 40 miles northwest of Jatibonico, site of the wildcat drilled by Kerr-McGee on the Dos Estrellas concession.

PERU

★ Latest reports on the Peruvian operations of Douglas Oil Company of California indicate that Douglas Lobitos Well No. 1 has picked up the first stringers of oil sand of the Lobitos deep zone. One 20-ft interval of permeable oil sand was encountered between 6445 and 6465 ft.

The Lobitos deep zone, which usually runs from 600 to 1000 ft in thickness, consists of stringers of oil sand and shale. It is productive in onshore areas contiguous to the Douglas concession. Lobitos No. 1 is making hole on the company's Pacifico concession, having crossed over from the Lobitos concession at 6430 ft.

Another well, Douglas Pacifico No. 1, also being directionally drilled from the beach to offshore objectives, is exploring ahead at 5993 ft in sand and shale. This is the company's first well on its Pacifico concession.

ISRAEL

★ Tri-Continent Drilling Company, a subsidiary of Pantepec Oil, has initiated a core drill survey in Israel. Operators contemplate initially a six well program to evaluate partially the 800,000 acres held under lease by the Mediterranean Petroleum Corporation and Pan-Israel Oil Company.

NORTH DAKOTA

★ The Amerada-Erickson No. 1 located in Section 15, Township 158N, Range 94W, Mountrail County, North Dakota, was completed as a successful producing oil well, proving a new oil field. This well flowed 393 bbl of 38.2 gravity oil from Madison lime formations through perforations at 8298 to 8308 ft through a 14/64-in. choke with tubing pressure at 750 lb.

OIL YEARBOOK

★ Rinehart Oil News Company, national oil reporting firm, announces the distribution of its 1954 Yearbook.

The new double-volume reference book represents the end product of more than 222,000 words reported daily on oil and gas developments throughout a 20-state area. The information is compiled by specific geologic areas and states, including historical data on all key wells.

The 1954 edition carries a series of ten multi-colored columnar charts and cross-sections. Prepared by the Rinehart staff, this original material depicts the stratigraphic position of geological formations in four extensive oil provinces, complete with an alphabetical index of 2087 names used in the areas covered by this latest yearbook.

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Wayne Rogers

John Stein

Fritz Seyfarth recently joined the staff of Cable Engineering, Wichita Falls, Texas. He was formerly with Standard Oil Company of Texas. A graduate of Texas A and M, Seyfarth will engage in secondary recovery studies, evaluation work, plant installation, and core analysis work.

Wayne Rogers has been promoted to district engineer of the British-American Oil Producing Company's central district in Oklahoma City. He succeeds Gordon J. Buckle, who recently was made district superintendent of the southern district. A graduate of Texas A and M College, Rogers joined British-American as an engineer trainee in 1949. He later was promoted to junior petroleum engineer and served in Wyoming and Tulsa. Rogers was stationed in Dallas as a petroleum engineer at the time of his appointment.

John Stein has been named projects engineer of the northwestern district of British-American. He was petroleum engineer at Steamboat Butte near Riverton, Wyoming, before assuming his newly-created position. Stein joined British-American in 1949, after graduating from Missouri School of Mines. After receiving training in several oil fields he was promoted to junior petroleum engineer in 1950, serving in the northwestern district and Tulsa.

Frank A. Morgan, vice president and manager of exploration of Richfield Oil Corporation, has resigned effective in June. Morgan has served as vice president and exploration chief of the Richfield organization since the formation of the company in 1937. Prior to that time he was chief geologist for the Rio Grande Oil Company.

John H. N. Evinger has been named production superintendent for Falcon-Seaboard Drilling Company at Fort Morgan, Colorado. A graduate of Oklahoma University, Evinger has worked for several companies in various capacities. He was with A. N. Hendrickson, Midland, Texas, before joining Falcon-Seaboard.

Claude E. Leach is manager of exploration in the exploratory department of the newly created central division of Tide Water Associated Oil Company in Tulsa, Oklahoma. A graduate of Stanford University, he joined Tide Water in 1930. His work with the company has taken him from California to Alaska and Canada. He was manager of the geological department of the Mid-Continent division before his appointment.

L. K. Lancaster was appointed division geologist. He was assistant chief geologist at Houston before his move. Lancaster had several years experience in the mining industry before entering the petroleum field. He is a graduate of the University of Minnesota. **Cecil M. Keller** has been named division landman. He joined Tide Water in 1937 as a scout. Keller was assistant to the chief landman in Houston at the time of his appointment.

Leo W. Stach of Tokyo, Japan, technical consultant for development of oil and natural gas resources in the Far East, has accepted an assignment for one year as petroleum geologist with the United Nations Technical Assistance Mission to Taiwan (Formosa). He will advise and assist the Chinese Government in exploration and development of petroleum resources.

Lon D. Cartwright, Jr., has resigned as manager of exploration for the eastern area of Union Oil Company, to become a vice president of Cyprus Mines Corporation and Cyprus Oil Company. He will be in charge of oil operations.

Charles E. Dimit has resigned as vice president of Creslenn Oil Company. He will devote his efforts to developing oil production in the Rocky Mountain area with offices in Denver, Colorado.

Ed O. Peschke, Baker Oil Tools, Inc., above, receives award from John G. Pew, Sun Oil Company, at the spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute, Los Angeles, recently. In center is Milan G. Arthur, Union Oil of California, who also received an award from Pew.

New officers of Pacific Coast district elected by the API group are: Standing, John Van Riper, Continental Oil, vice chairman for Coastal area; Lot Bowen, Western Gulf, chairman, advisory committee; I. B. Doyle, Hydril, assistant treasurer. Seated, Elsie Edmiston, API, secretary; C. F. Gates, General Petroleum, chairman, Pacific Coast district; Hugh C. Mays, Crescent Petroleum, vice chairman, San Joaquin Valley. Not shown, E. M. Benson, Jr., Richfield Oil, vice chairman, Los Angeles Basin; Jack Lemley, Standard Oil of California, vice chairman, Coalinga-Kettleman area, and Charles T. Reichert, National Supply, treasurer.

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McCullough Standard Casing Glass Jet Perforators with Steel Strip Carriers used to shoot 618 holes in 5½", 17 lb. casing. Two runs in the hole were made, perforating eleven zones between 6118' and 6290'. First run perforated five intervals with 294 shots. Second run perforated six intervals with 324 shots. Strips were blanked off between zones. Total rig time 3 hours. Well was perforated from McCullough Gamma Ray and Neutron measurements.

Results After Others Failed

Well perforated by McCullough after two failures to get penetration by other make perforator. McCullough 3½" M-3 Bullet Perforator fired 32 shots in 5½" O.D., 17 lb. cemented casing between 7112' and 7120'. Results: From zero production to 600 barrels per day. Rig time: one hour.

0 B/D to 550 B/D — 3½ Hours

Casing: 5½", cemented in 8⅝", cemented in 11" hole. McCullough Super Casing Glass Jet Perforator with Steel Strip Carrier fired 232 shots between 8160' and 8218'. Well was acidized and made 550 B/D clean oil on 24 hour test. Time on the job: Three and one-half hours.

Fast, Efficient Service

Set six Type "B" Bridge Plugs and perforated seven zones. Perforating averaged 16 holes per job, eight holes per foot. McCullough 4¼" M-3 Bullet Perforators were used. Casing was 7", 23 lb. cemented in 9⅝" hole. Depth of operations was between 2500' and 2600'. Average time to set one plug and perforate one zone—one hour and 45 minutes.

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To obtain more information on products advertised see page E-61

Running Tour

Hames M. Dawson has been named division land superintendent of Continental Oil Company's new division exploration office at Ardmore, Oklahoma. A graduate of Oklahoma University, Dawson joined Conoco in 1948. He was division land superintendent at Wichita before moving to his new post. **Dan Nisley** was appointed division geologist. He has been with Conoco since graduating from Western Reserve University in 1948. **Graham Fenner** was named geophysical supervisor of the new division office. He joined Conoco after graduating from Western Reserve in 1948. He was formerly geophysical superintendent at Oklahoma City.

Joe Gill has been promoted to assistant division land superintendent for Continental Oil Company in Oklahoma City. A graduate of Austin College, Gill joined Conoco in 1952 as a scout and leaseman in the Oklahoma City area. **Ben W. Smith** was promoted to geophysical supervisor in Oklahoma City. Smith served with Continental geophysical crews after joining Conoco in 1946, until he was transferred to Oklahoma City in 1953. He is a graduate of the University of Mississippi.

Bernard A. Taylor has been transferred to Casper, Wyoming, as district geologist for Sohio Petroleum Company. He joined Sohio in 1946 and was promoted to Houston district geologist in 1952, which position he left to move to Casper.

R. W. Norton has been appointed field superintendent by Standard Oil Company of California, of its Newhall-Ventura, Santa Maria areas, southern district. His successor as field superintendent, Bay area, will be **G. C. Beckman.** A third appointee, **Kistler Wagy,** was named management assistant in the San Francisco office.

Patrick Daugherty has resigned as geologist for McCarty and Coleman at Billings, Montana. He has worked for McCarty and Coleman in the Rocky Mountains and Canada for the past four years. Daugherty plans to operate as an independent.

Richard A. Grant, Fullerton Oil Company, has been re-elected president of Oil Producers Agency of California. **R. R. Von Hagen,** Lloyd Corporation, was elected a vice president. **H. D. Campbell,** Franco Western Oil Company, and **W. H. Geis,** consultant, were re-elected vice presidents.

S. E. Cavanaugh, Pacific Western Oil Corporation, was elected secretary and treasurer and **Verne Harrell,** Bankline Oil Company, was re-elected assistant secretary and treasurer. **Stark Fox** was re-elected executive vice president.

A. Knox Tyson, who resigned recently from American Republics Corporation has joined the Slick-Moorman Oil Company. Tyson was president and director of American Republic and had formerly been associated with Continental Oil.

Alvin R. Winzeler, Stanolind Oil and Gas Company, Canadian division, has been named division exploration superintendent; **Robert O. Mitchell** succeeds Winzeler as division geologist, and **C. O. Hopper, Jr.,** moves up from field superintendent to the post of district superintendent for producing operations.

Winzeler, who has been division geologist since Stanolind's Calgary division was opened in 1948, joined the company in 1936. He is a graduate of the University of Wichita. Mitchell began as a geological scout in 1941. After various assignments he came to Calgary as a senior geologist in 1950. He is a graduate of Oklahoma University.

Hopper joined Stanolind in 1947, and went to Calgary in 1952. He is a graduate of the University of Texas.

Other changes include establishing of a division law department in the Calgary office and an area producing office at Edmonton. **Neil J. Stewart,** formerly in the division land department becomes attorney and will handle legal matters of the division. Stewart was graduated from the Universities of Alberta, and British Columbia. He was employed in 1953.

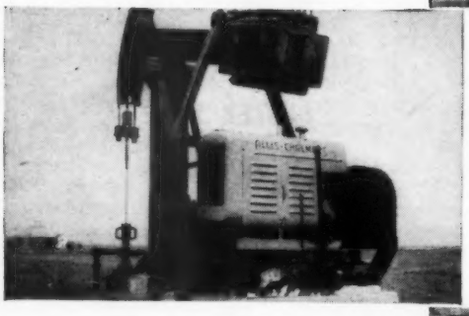
In charge of the new Edmonton area office is **Clifford F. Rakestraw,** production foreman. He began his Stanolind career in 1941, and was farm boss in the Rangely area at the time of his promotion and transfer to Calgary.

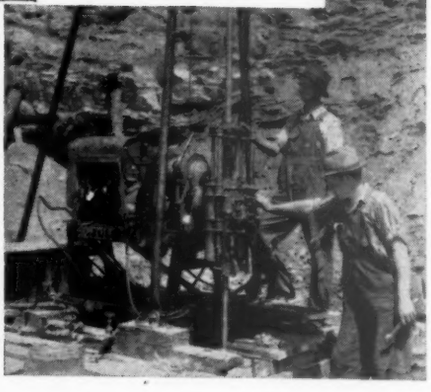
H. W. Hinkle, Jr., has been named field engineer for the new area. A graduate of Oklahoma A & M, Hinkle joined Stanolind in 1947. He was formerly field engineer in Farmington, New Mexico.

C. E. Dagley, who came to Calgary in 1953 as field clerk, is promoted to district clerk. He has been with Stanolind since 1941. Dagley is succeeded by **Clarence E. McBurnette,** who was transferred from the Hendrick area of West Texas where he held the same title.

Andrew F. Holan, junior petroleum engineer, has also been assigned to the Edmonton office. He is a 1953 graduate of the Montana School of Mines, and was employed in 1953. **John B. Maughan** has joined the division office staff in Calgary as petroleum engineer. Maughan is a graduate of the University of Oklahoma.

HOW TO GET THE RIGHT CLUTCH





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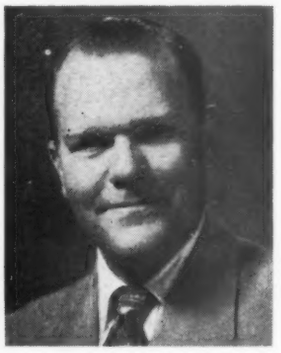
Visitors at the April 12 meeting of the Houston Nomads were: Back row, G. Bouche, SNPA, Paris, France; Harold Hall, Reed Roller Bit, Maracaibo, Venezuela; Tony Volotko, Mission Manufacturing, Houston, Texas; Ted Lemcke, Reed Roller Bit, Los Angeles, California. Front row, Ellis Garlington, Jr., Rolo Manufacturing, Tulsa, Oklahoma; Jack Ballagh, Jet Lube, Los Angeles; Howard Book, Reed Roller Bit, New York City, and W. P. Larkin, Glenn McCarty, Yacuibe, Bolivia.

George R. Bryant, vice president, The Texas Company, was guest speaker at April 12 meeting of Houston Nomads.

Stanwood I. Williams

Roscoe Clark



Ted G. Ward, Jr.

▸ **Stanwood I. Williams** has been elected president of Thomas P. Pike Drilling Company. He succeeds Thomas P. Pike, recently named Assistant Secretary of Defense.

Howell G. Haney was named to a newly created post, chairman of the executive committee of the board of directors. **Gene Graham** was elected to the position of executive vice president vacated by Williams.

▸ **Roscoe Clark** has joined the staff of The Western Company, technical oil and gas servicing concern with general offices at Midland. He will assume duties of coordinating all Western research in acidizing, fracturing, perforating and radioactivity well logging.

Clark, a graduate of Tulsa University, was formerly with Stanolind Oil and Gas and Continental.

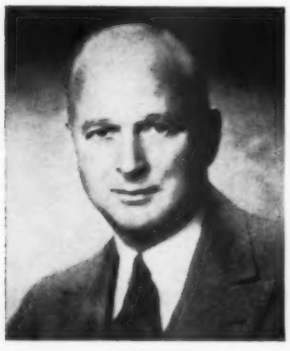
▸ **Ted G. Ward, Jr.,** has recently joined the firm of Buckles and Hostetler, oil production consultants, in Monahans, Texas, as chief engineer. For the past several years he has been specializing in water flooding in West Texas; having been associated with Atlantic, Reno, British-American and Richardson and Bass. Ward is a graduate of the University of Oklahoma.

▸ **W. B. Hopkins,** Gulf Oil Corporation, has been named chairman of the American Institute of Mining and Metallurgical Engineers. Other officers include: **James K. Jordan,** vice chairman, Humble; **Herman A. Engle, Jr.,** Union Sulphur and Oil, secretary-treasurer; **R. C. Craze,** Humble, council of section delegates. Directors are: **W. R. Purcell,** Shell; **R. M. Rutledge,** Lane-Wells; **Roy A. Bobo,** Phillips; **H. M. Krause,** Humble, and **Kenneth B. Ford,** Butler, Miller, and Lents. **Milton Cooke,** consulting engineer, is chairman of membership committee.

▸ **M. S. Kendrick** has been appointed to the newly created position of coordinator of offshore operations for Continental Oil Company's southern region. He was associated with Creole Petroleum Company in South America until his recent appointment. Kendrick attended the United States Naval Academy, and Harvard University.

▸ **Jack A. Falkenberg** has been appointed land and lease manager for Oceanic Oil Company. He resigned as assistant division landman of The Texas Company's Pacific Coast division to accept the Oceanic post. Falkenberg was with The Texas Company for 23 years, serving in various capacities in the company's land department.

▸ **B. F. Gilchrist,** of Gilchrist Drilling, has been named chairman of the West-Central chapter of American Association of Oilwell Drilling Contractors. **George M. Straughan,** of Lauderdale and Straughan Drilling, is vice chairman and **George D. Hunter,** of General Geophysical, secretary and treasurer.



S. P. Farish

R. G. Hamaker

W. B. Noble

E. F. Snow

H. C. Tooley

Stephen P. Farish is new board chairman of Reed Roller Bit Company. Farish who has been president since 1925, is succeeded by R. G. Hamaker, former vice president in charge of sales. Other new promotions in the company include that of H. C. Tooley, former vice president, manufacturing, who is new executive vice president; W. B. Noble, first vice president in charge of engineering, and E. F. Snow, second vice president and treasurer. Both were vice presidents.

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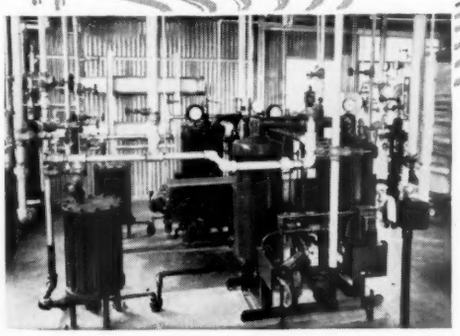

This fully automatic Lectrodryer DRYs instrument air prior to its being fed to the many pneumatically operated instruments at the Stanolind Oil & Gas Company's Stano Gasoline Plant, Ulysses, Kansas, pictured above.

"There's no cause to worry if you DRY instrument air. It assures trouble-free operation." These statements were made by the Stearns-Roger Company of Denver, the firm that engineered the Stanolind Oil & Gas Company plants of the type pictured.

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Catforming Units

The Atlantic Refining Company has announced it is planning to build new catalytic reforming units.

The process, termed catforming by Atlantic, is a continuous, fixed bed process that functions to produce high octane motor fuel at high yields from any feed stock without feed preparation, or product after-finishing, and normally without catalyst regeneration. J. P. O'Donnel has been awarded contract for plants.

★ ★ ★

Economy Is Sound

The economy doesn't look bad at all for the first quarter of 1954. For January, February, March 1954, goods and services amounted to $30 billion per month; for the same three months in 1953, they averaged $31 billion. Most of this drop is attributable to less spending on inventories, a normal expectation, and nothing to be feared. Continued rise of the stock market is an apparent reflection of the soundness of the economy.

★ ★ ★

South African Plant

South Africa's tremendous installation for conversion of coal to synthetic gasoline, oils, and chemicals is approximately 60 per cent complete. This largest expansion of synthetic fuels methods in the world will convert 7600 tons of coal and raw products daily into the main products, utilizing both German and American processes. Coal will be gasified to form synthesis gas.

Normal annual production will be around 55,000,000 gal of gasoline, 4,500,000 gal of gas oil, about 1,500,000 gal of fuel oil. In addition 15,000,000 gal of industrial chemicals, ammonium sulfate, and aromatics will be produced.

★ ★ ★

ACS Research Fund

First meeting of the Petroleum Research Fund Committee of American Chemical Society was held late in March, in Kansas City in connection with the meeting of the Society. Fund is made of profits from operations of Universal Oil Products, and is used to support and foster research in all phases of the industry. Grants-in-aid to college professors, post-doctorate fellowships are to be made upon applications after careful consideration. Also, projects like those supported by API and those under way through that program and to be supported.

Advisory Board is composed of Cary R. Wagner, chairman. Membership is for terms of three years, with one-third the membership to be replaced each year. Members are: Paul H. Emmett, University of Pittsburgh; Wheeler G. Lovell, Ethyl; J. K. Roberts, Standard Indiana. For 1954-55 membership (2 years); Gustav Egloff, UOP; W. F. Libby, Chicago University; R. W. Richardson, Standard Louisiana; for full terms, 1954-56, Fred E. Frey, Phillips; W. E. Kuhn, Texaco; Kenneth Pitzer, California University. Ex-offiicio members of the board are: Chairman of the petroleum division, ACS, now F. D. Rossini; Hugh W. Field, chairman of API ACFRCPP, (research committee): Atlantic; T. W. Nelson, chairman API, ACFRORP committee, Socony-Vacuum.

★ ★ ★

Ammonia Producers

Monsanto Chemical has released 80,000 ton certificate of necessity on ammonia capacity, which can be taken up by other firms. This adds more than 160,000 tons available capacity for certification. A dozen firms have applied for certificates in the last 2½ months. Plants of smaller capacities may get certification easier.

★ ★ ★

Butadiene Plant

A new butadiene-from-petroleum plant is being studied carefully by private interests with a view to building it somewhere in Texas. Backers are William R. Staats and Company, Los Angeles, Purvin and Gertz of Dallas, and other interested parties. The plant would be designed for 80,000 tons of butadiene per year, but would be operated initially at half that capacity.

Plan for this unit would utilize the production to supply needs of manufacturers of plastic paints, plastics, and nylons, etc. With present government plans to dispose of their synthetic rubber and affiliated plants, it is expected eventually that this plant operation would be stepped up to supply butadiene for the expanded synthetic rubber demands of the nation. The firm of Purvin & Gertz is retained as consultants. The Fluor Corporation has been commissioned to make preliminary estimates and studies of the project.

Facilities Expanded

A 50 per cent expansion of facilities for manufacture of ethanolamines will be carried out soon by Jefferson Chemical Company at its plant at Port Neches, Texas. Much of this product will go into the making of morpholine, a new chemical intermediate being brought out by Jefferson. Facilities also will be expanded to enable the production of mixtures of the mono-, di-, and tri-ethanolamines to meet requirements of a great number of applications of this versatile chemical "family."

★ ★ ★

Air Pollution Control

Many large corporations are requiring a staff experts' spot portfolio, because of the extreme and growing importance of controlling air pollution. Large issues are at stake, and the complex situations call for highly trained attention. W. E. Rand, research director in physical sciences at Stanford Research Institute, said in talking before the Southern Industrial Wastes Conference at Houston, Texas. Greatest function of this "Expert" is in spotting trouble before it reaches the severe stage. Such foresight effects tremendous savings on occasion, for companies, and avoids damage to public relations in local areas.

★ ★ ★

Building Canadian Plant

A new $20,000,000 refinery for Canadian Petrofina, Ltd., is under construction near Montreal. Plant will be designed by M. W. Kellogg's Canadian subsidiary, to operate on either Venezuelan or Middle East crudes. It will include a 20,000 bbl per day crude distillation unit, a Standard of Indiana Ultraforming unit, all other required facilities, and will be completed by late 1955.

★ ★ ★

Ashland Houdriformer

A 6000 bbl per day Houdriformer unit will be built at Catlettsburg, Kentucky, for Ashland Oil & Refining. Ashland will charge naphthas from Illinois, Louisiana, and Kentucky crudes to make high octane number gasoline (reformate), naphtha specialties and solvents. Ashland has operated a Houdry cat cracker for 10 years.

Corrosion Costs High

The U. S. Oil refining industry is losing $280,000,000 annually by corrosion of its equipment, says J. D. Munro, Standard Oil Development Company. Strange or not, the worst criminal in this is water, not acids, or other materials. New heat exchanger equipment costing $100,000,000 per year is added by the industry; exchangers are in constant contact with water on either one or both sides, probably the worst situation in the refinery. Corrosion has cost Jersey Standard as much as $90,000,000 per year, $33,000,000 of it at home, the rest abroad.

★ ★ ★

"Ultraperfect" Carburetor

Another rumor-powered "Flying Saucer," one of the Hydraheaded family of reports of carburetors not offered to the public has been shot down again. It is the carburetor designed by Charles Pogue of Toronto, Ontario, in 1936, reported to give "200 miles per gallon of fuel," which had been suppressed by intimidation of the designer "Who never put it into production after the oil companies got panicky and put the pressure on him."

After story was run down by a Sun investigator, it was found actual carburetor was based on U. S. Patent No. 2,026,798, issued January 7, 1936, to Charles N. Pogue, Canada. Pogue says no oil company or anyone else ever tried to suppress it. "I tried to suppress the wild rumors . . . told them I had made none of the wild claims . . ." finally dropping work on the unproved design and began to develop a more conventional type."

★ ★ ★

Technical Men Not Scarce

It is only in the brackets of technical men with several years experience that it is now difficult to fill jobs in industrial companies, says Dick Moore, personnel chief for Foster D. Snell, Inc. Jobs are "not galore" now. For college graduates, small companies are paying $275-300, says *Chemical Week*; large companies may go up to $325, tops in New York area, $365 per month.

★ ★ ★

Companies to Merge?

Strong rumors that Mathieson Chemical and Olin Industries, Inc., already linked together in one subsidiary, may make a complete and formal merger in the future, if nothing upsets the applecart. The two are joined in the Matholin Corporation, to make hydrazine, powerful and versatile chemical intermediate, at Lake Charles, Louisiana.

★ ★ ★

Union Turned Down

Queer reports come out of here and there nowadays, about reactions of employees to the demand that they choose between CIO and AFL unions as bargaining agents in relations with their employers. One of the latest — B. F. Goodrich, who has vinyl chloride plant at Calvert City, Kentucky. Working to organize employees the two big union combines demanded and got an election called. Out of 55 people, 11 voted for CIO Gas-Coke; one lone ranger went for AFL Machinists, and the remaining 41, three-fourths of the total staff, said no union, emphatically. Looks like those 41 don't appreciate some things "properly."

★ ★ ★

Unifining Unit Planned

Union Oil will build a Unifining unit of 450 bbl per day capacity, for $100,000 at its Cut Bank, Montana, refinery. This process employs a cobalt molybdate catalyst to desulfurize feedstocks in the presence of excess hydrogen gas. Process is licensed jointly by Union Oil and Universal Oil Products Company.

★ ★ ★

Chemical Consultants

The firm of chemical consultants, Foster D. Snell, Inc., is prepared to act in a consulting capacity to the refining and petrochemical industries, recent announcement states. Special attention is to be given to the small refiner who may consider his company too small to warrant employing a large consultant firm, or for whom the large firms may not appear to have time. Snell will also design units for removal of mercaptan and hydrogen sulfide sulfur.

★ ★ ★

New Silicone Rubber

Time was when hydrophobic would send shivers up the backs of everyone with hearing, and though not pleasant even now, we still have "mad dogs" on occasion. But a gentle member of the "family" has come along with hydrophobic silica used in a new silicone rubber with high tensile strength, 2000 psig, 900 per cent elongation, and all the good things. Should be in production in fall or winter, 1954.

Asphalt Plant Expansion

A one-third increase in asphalt output at its Perth Amboy, New Jersey, plant has been accomplished by Witco Chemical Company. A 60 by 100-ft space was added to the cooling and shipping shed, thus speeding up operations in this one step.

★ ★ ★

Platformers to be Built

The Texas Company will build six Platformer units this year. Three alkylation units, a hydrotreater, and an isomerization unit also will be added. In April work began on Texaco's second Platformer, at Port Arthur, Texas, 20,000 bbl per day first unit, to be on stream in early summer.

Eagle Point Plant, New Jersey, — a 12,000 bbl per day unit will be built, and a 2000 alkylation unit. Los Angeles — a 10,000 bbl per day Platformer, 1000 bbl isomerizer, and a hydrotreater. Lockport, Illinois, refinery — will begin a 11,000 bbl per day Platformer this summer; 1000 bbl per day of alkylation capacity. West Tulsa refinery — a 9000 bbl per day Platformer, building this summer. Lawrenceville, Illinois, refinery—work begun on 13,000 bbl per day Platformer, 2250 bbl per day alkylation unit.

Cost of this expansion work will be around $275,000,000.

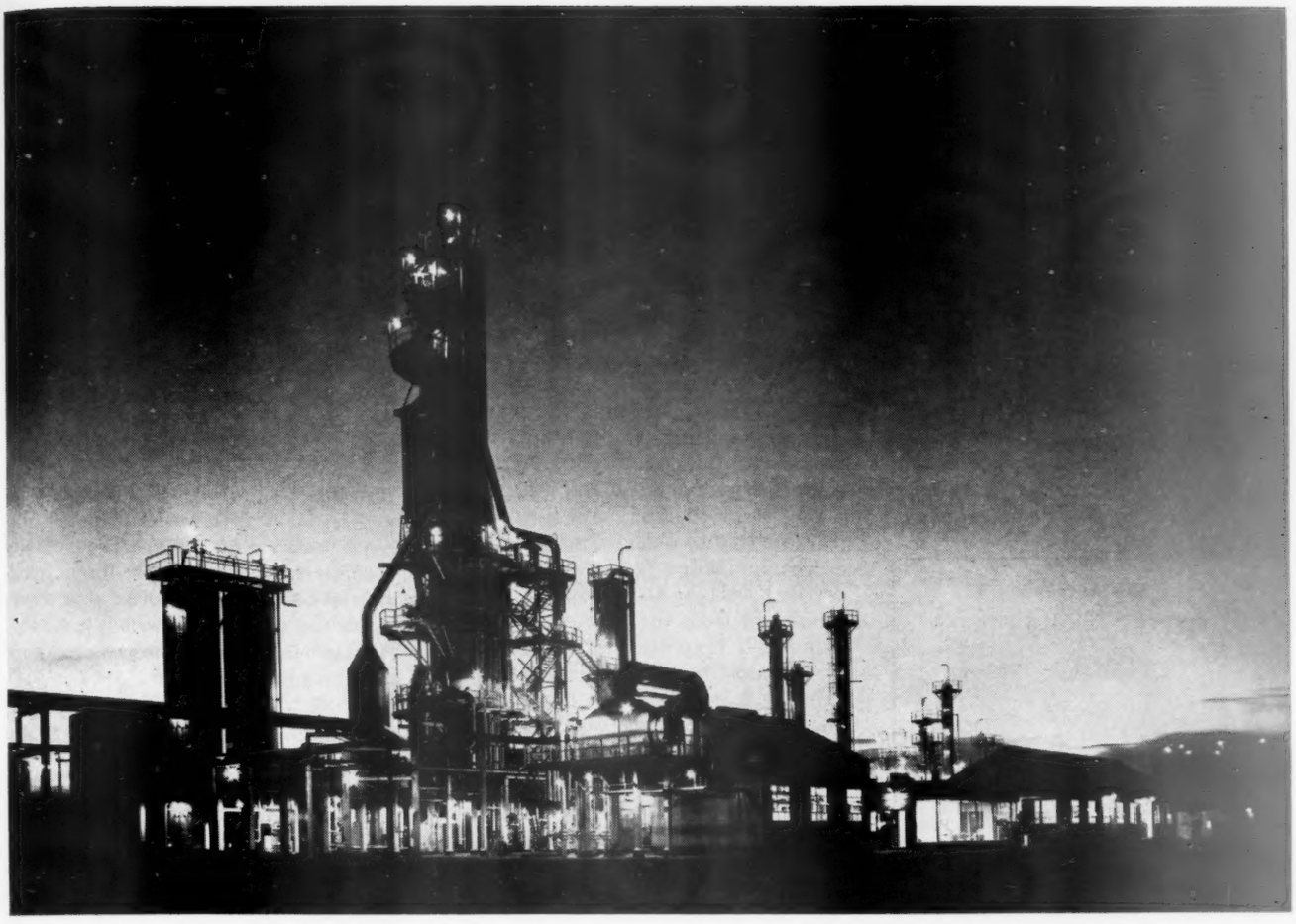
★ ★ ★

Oil Cuts Rubber Costs

Addition of special fractions of petroleum oils, made in regular refinery operations have been applied so successfully to the expansion of synthetic — GR-S — rubber that this product has forced itself into 18 per cent of the American synthetic sales, reports say. Most of the 160,000 tons produced goes into the making of tire treads.

Oil added to GR-S becomes an extender; 25 per cent by weight of 2-cent per pound oil, added to 100 per cent of polymer makes up to 125 lb of synthetic rubber. This reduces the cost of finished rubber from 23 cents per pound, for un-oiled polymer, to 18.8 cents for the extended product. The oil is referred to as an internal lubricant. G-RS is polymerized to higher molecular weight, harder consistency, and then 'cut back" with the oil to a workable state as wanted.

Also making is an extra-extended mixture of 100 parts polymer, 50 parts of oil (carbon) black, and 25 parts of liquid oil. These innovations are employed so far only in making "cold" rubber.



The co-op refinery at Phillipsburg, Kansas draws crude oil from Kansas, Colorado, Wyoming, and Nebraska wells. It supplies refined fuels to local cooperatives concentrated in northwestern Kansas and southwestern Nebraska.

Farmer-Owned Refineries in Kansas

Kansas had first farmer-owned refinery in the world; today it has four with total capacity of 61,000 barrels

JERRY CARTER

FIFTEEN yeas ago construction began on the first farmer-owned refinery in Kansas, the first of its kind in the world.

This refinery was situated at Phillipsburg in the northwest part of the state and built by Consumers Cooperative Association, Kansas City, Missouri. It did not long remain the only farmer-owned refinery, for in 1943, three more Kansas refineries were purchased by cooperatives.

These three refineries at McPherson, Coffeyville, and Chanute, plus the one at Phillipsburg, are today the total farmer-owned refinery output of Kansas.

CCA had considered the possibility and advisability of acquiring a refinery for several years. Finally the decision was made, and in July 1939, construction began on the Phillipsburg refinery. In December the first crude oil flowed into the 3000 bbl per day plant, and on January 1, 1940, Cooperative Refinery Association, the petroleum products subsidiary of CCA, turned out the first refined fuel at the plant.

EXCLUSIVE

It was soon evident after the start of World War II that cooperatives must expand their petroleum operations in order to adequately supply their farmer members throughout the Midwest and Plains states.

In 1943 a total of six state wide and regional cooperatives moved into the field of refining. Missouri Farmers Association, a statewide organization with headquarters at Columbia, Missouri, purchased a refinery at Chanute, Kansas. This 2100 bbl per day plant draws crude from a radius of 20 miles through an 85 mile gathering system

extending into Allen, Wilson, and Neosho counties. MFA owns two small oil leases that produce about 150 bbl per day.

Next Kansas refinery to come under farmer ownership was the 17,500 bbl a day plant at McPherson, which was purchased by five regional cooperatives incorporated as the National Cooperative Refinery Association. These five organizations that still own and operate the plant for some 2100 local cooperatives throughout the Midwest are:

Central Cooperative Wholesale, Superior, Wisconsin; Consumers Cooperative Association, Kansas City, Missouri; Farmers Union Central Exchange, Inc., St. Paul, Minnesota; Farmers Union State Exchange, Omaha, Nebraska; and Midland Cooperatives, Inc., Minneapolis, Minnesota.

The McPherson refinery was purchased about mid-year, 1943, from the Globe Oil and Refining Company. In the last four years an extensive modernization program has been carried on. In 1951 a catalytic cracking unit, and gas concentration and polymerization units were completed. In November, 1953, a coking unit was added, making it one of two refineries in Kansas with a modern coker. General manager Ralph Booker feels the coking unit is especially suited to a cooperative refinery, because it enables the plant to produce a higher quantity of light fuels which can be used by the member owners themselves, rather than turn out a large proportion of heavy fuels which must be sold to outside firms.

The remaining farmer-owned refinery in Kansas is at Coffeyville. It was purchased from the National Refining Company, becoming the property of Consumers Cooperative Association on January 1, 1944. At the time of purchase this plant had a capacity of 13,500 bbl of crude oil a day and has since been enlarged and modernized to a capacity of 25,000 bbl. It included the first cooperative lubricating oil refining unit, and continues today as a producer of high quality CO-OP lubricants. The lube oil operation turns out about 39,000 bbl of lubricants per month.

Also at this site was a government owned aviation gasoline refinery that was operated during the war years and later purchased by CCA. The Coffeyville plant, though originally built in 1907, has been kept up to date with modern equipment and processing units to maintain its place in the industry.

Latest complete farmer-owned refinery modernization has been at Consumers Cooperative Association's Phillipsburg refinery. In June 1953, catalytic cracking and polymerization units were built and existing units were revamped, bringing capacity of the plant from 4000 to 8000 bbl of crude oil daily.

Present official rated capacity of the four farmer owned refineries in Kansas totals 61,000 bbl a day which compares to total rated capacity of 14 refineries in Kansas of 272,025 bbl. This gives the cooperatives about 22 per cent of the total Kansas figure.

These cooperatives have about 1500 oil wells, most of which are in Kansas. Products from the four refineries go to local cooperatives in some 15 states in the Midwest and Great Plains sates. The MFA refinery at Chanute serves farmers in southeastern Kansas and in southwestern Missouri.

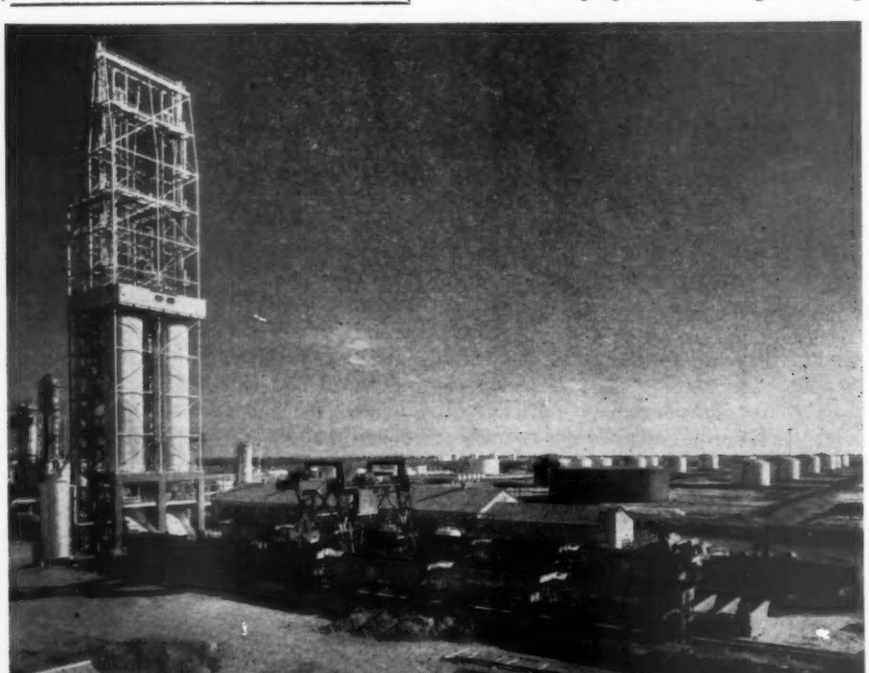
Cooperatives situated from Wyoming, the Dakotas, Minnesota, and Michigan on the north, down through Missouri and Oklahoma on the east and south receive petroleum supplies from these cooperative refineries. Almost a million farmer members are potential customers in areas served by co-op service stations which are supplied by farmer owned refineries in Kansas.

This is the story of one phase of the progress of the petroleum industry in the Sunflower State. Development from one small, struggling refinery under construction in July 1939 to four efficient plants in July 1954 has made cooperatives one of the larger independent refiners in the state. * * *

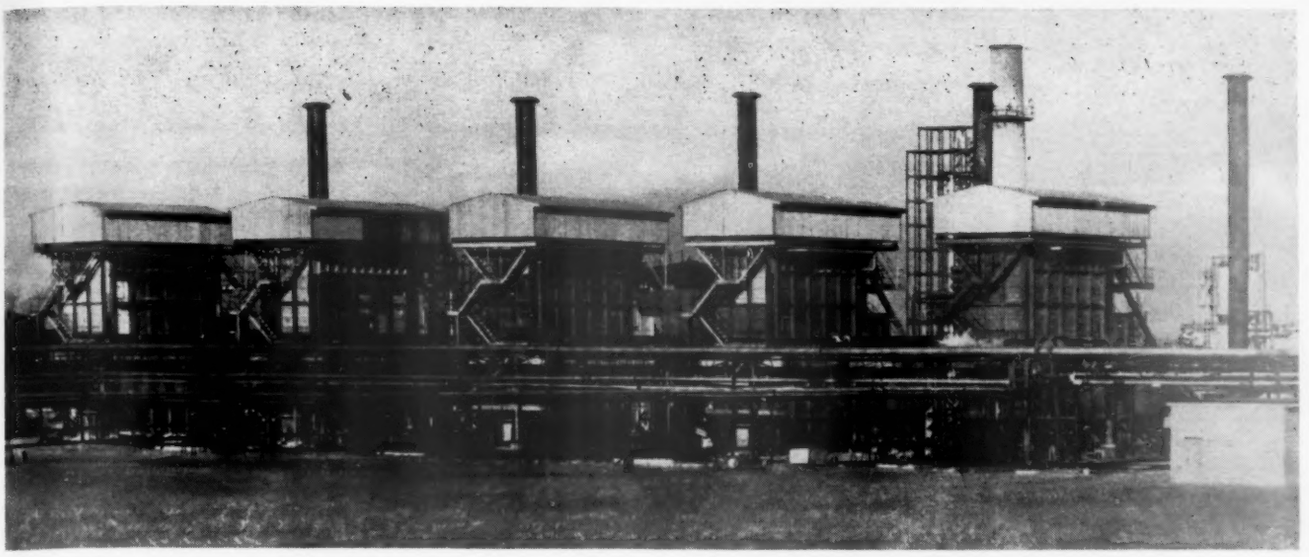
Howard A. Cowden is president of Consumers Cooperative Association, which he helped organize in 1929. He probably has done more than any other for development of cooperative petroleum operations throughout the world, as well as in Kansas. He has been in farm cooperative work since his youth in Missouri.

The Author

Jerry Carter is in the Information Division of Consumers Cooperative Association, Kansas City, Missouri. A graduate of the University of Missouri in agricultural journalism he was formerly with the National Livestock Producer Magazine in Chicago, and served with Army Intelligence.



Coking unit completed in November last year at National Cooperative Refinery Association plant in McPherson.



FIVE OF the Catarole catalytic cracking units which convert ligh. petroleum distillates in a continous operation to aromatic hydrocarbons and light olefinic gases — ethylene, propylene, etc.

U. K. Petrochemical's Catarole Units in Full Operation

Production of highly cracked distillate of more than 90 per cent aromatics boosts chemical manufacture

V. S. SWAMINATHAN

THE plant of Petrochemicals Limited at Partington near Manchester, England, was conceived as an integrated group of units producing a wide range of basic aromatic and aliphatic chemicals, and as a nucleus for subsidiary installations for their future processing. This pioneer project, based wholly on British work and patents, is founded upon the "Catarole" process for the production of olefines and aromatics by the "deep cracking" of petroleum distillates.

The first cracking furnace came on stream in January 1949, and by the beginning of 1951 most of the major production units were brought into production. Only recently most of the teething troubles were overcome and the plant is now operating satisfactorily. In this relatively short period an annual output of 525,000 bbl of key products needed by the modern organic chemical industry have been made available. Nearly 50 per cent of this total is earmarked for export, a very useful contribution to the country's trade balance.

In this Catarole process the naphtha (150-250 C) is preheated and cracked at approximately 700 C and pressures of 20-50 psig. Products of cracking are rapidly quenched to 120 C.

Typical yields are as follows:

Input: Middle East naphtha (150-230 C)

	% w./w.	
Gases:		
Hydrogen and methane	15.0	
C_2's	22.0	
C_3's	11.0	
C_4's	2.5	
Gas losses	1.5	
		52.0
Liquids:		
Nitration benzene, Nitration toluene, Refined xylenes	14.0	
Styrene	0.5	
Solvent (150-190 C)	3.9	
Indene and methyl styrene resins	2.0	
Naphthalene	1.0	
Higher boiling solvents (230-300 C)	5.1	
Light solvents and polymers not included above	3.5	
Heavy oil and pitch	11.4	
Cracking and refining losses	6.6	
		48.0
		100.0

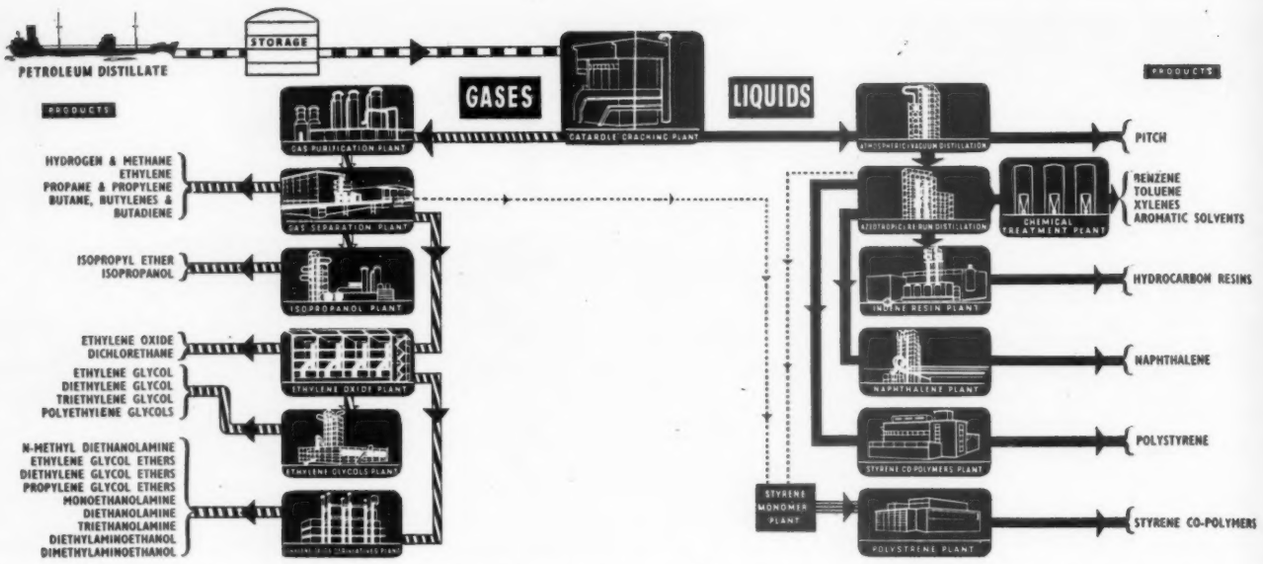
Liquid yield (expressed as per cent by weight on charge stock) from Catarole cracking is virtually independent of the boiling point of the charge stock over the range 100-300 C, but for any selected narrow range it is appreciably affected by the density of the charge. Thus, with a highly paraffinic charge stock the liquid yield (about 50 per cent) is lower than with a naphthenic feed (about 60 per cent), and this in turn is somewhat below the yield from a more aromatic feed.

The liquid product is highly aromatic (plus 90 per cent). The distillation curve of the highly aromatic product changes with the boiling range of the feed stock; if a naphtha feed (say, 150-250 C) boiling range is cracked, then some 60-70 per cent of the liquid produced boils below 180 C, whereas if a gas oil feed is used, the per cent of aromatics boiling below 180 C falls to nearly 40 per cent. The very high content of aromatics in the liquid product from Catarole cracking and the absence of sulfur, nitrogen and oxygen compounds, simplifies the recovery and purification of the products.

The gas separation plant of Petrochemicals Ltd. produces ethylene, a propane-propylene stream and a mixed C_4 stream. Ethylene is converted into ethylene oxide and glycol; proplyene into ispropyl alcohol, propylene oxide and propylene glycol, while the butylene stream is used at the moment as bottled gas, or as recycle feed stock.

The distinguishing feature of the plant is the working up of the liquid fraction. This material is wholly aromatic in nature, and by simple distillation procedures the usual aromatic coal-tar products — benzene, toluene,

EXCLUSIVE



DIAGRAMMATIC flowchart of Catarole process, showing primary cracking step and various product steps with main products made.

xylene, alkylbenzene, napthalene and alkyl naphthalene — are separated. The installation also produces resins obtained from styrene, alkylated styrenes and indene contained in the cracking products. Another noteworthy feature of the plant is the disposal of the residual gases (methane and ethane) which are piped to adjoining gasworks supplying Manchester.

Entailing an outlay of approximately £10 million, the present capacity of the Petrochemicals plant is 525,000 bbl of chargestock a year. The plant has been so designed, however, that its capacity could be increased to approximately 1,050,000 bbl per annum for a relatively small additional capital outlay.

In the liquid products of the Catarole process fractions boiling between 140 and 210 C contain between 30-40 per cent of polymerizable bodies consisting essentially of styrene and alkylstyrenes, indene and alkyl-indenes. Special techniques of polymerization have been developed, and a wide range of high quality light colored resins are now manufactured. These are either oil-soluble or non oil-soluble, and have excellent light stability and high melting points.

The intermediate boiling range fractions of Catarole liquid products, i.e., that portion boiling between 230-290 C, have high solvent power, chemical compatibility, a safe flash point, are non-toxic to animals, non-corrosive to metals and readily emulsifiable. These alkynaphthalenes are thus finding extended use as insecticides, herbicides and fungicides.

In this same boiling range certain narrow cuts, following further refining, possess considerable thermal stability. Resistance to thermal decomposition, coupled with other desirable properties, render them useful as heat transfer media. The higher boiling fractions are finding an important place in the dyestuffs industry.

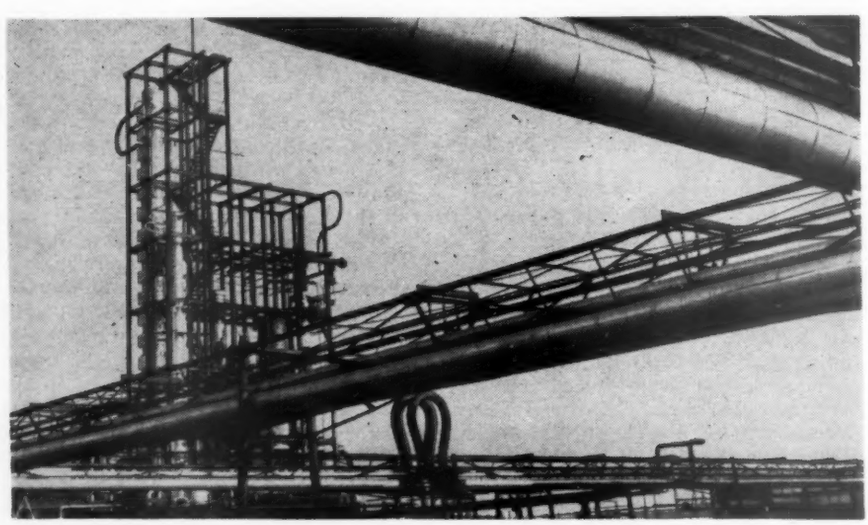
The prime requisite of a sound, prosperous chemicals from petroleum industry rests on an ample supply of cheap olefines, coupled with an economic method of their separation. The technique of separation of gases applied at Petrochemicals, Ltd., is in many ways outstanding. The complex mixture of cracking gases is cleaned, compressed and cooled under conditions whereby all but the hydrogen and part of the methane is liquefied at low temperatures and medium pressures.

The major part of the output of ethylene oxide is further processed into the manufacture of mono, di and tri-ethylene glycols; mono, di, and triethanolamines, and a comprehensive range of glycol and diglycol ethers. This is the first time that these essential chemicals have been made commercially in Britain by direct synthesis from ethylene obtained from petroleum.

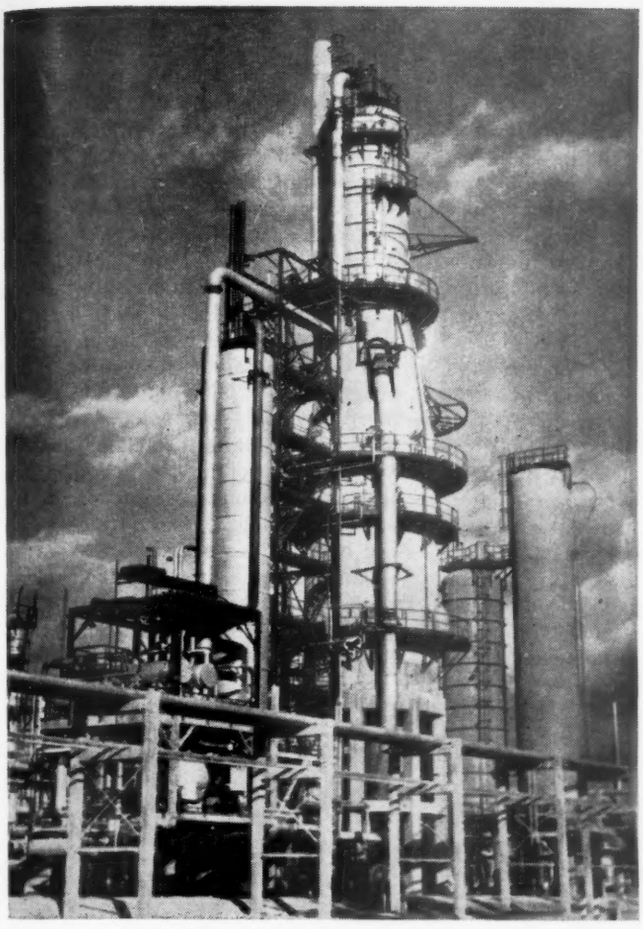
From the possible uses of propylene the manufacture of isopropyl alcohol was selected by Petrochemicals, Ltd. Now the company is producing propylene oxide and a range of derivatives therefrom, corresponding to those of ethylene oxide.

The many potentialities of the Catarole process entail very active research and development teams, alive to all new knowledge of the changing market requirements. The company's research and development groups fulfill this condition, and although in the early stages both groups not unnaturally devoted the bulk of their time to the various problems on the plants, the need for fundamental long-term research has not been overlooked and has, in fact, been actively pursued since its inception.

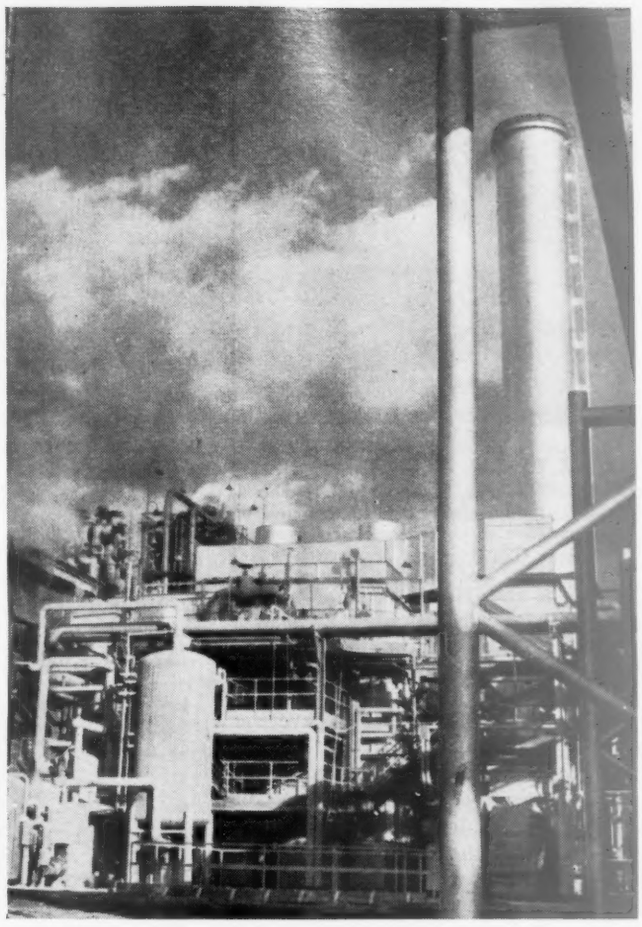
Many of its products are new and of a purity hitherto not obtained in large-scale production. As a link between research and development on the one hand, and consumers on the other, the company maintains close sales and technical liaison with clients at home and abroad. * * *



ISOPROPANOL UNIT. Here propylene from gas separation plant is converted to isopropyl ether and isopropyl alcohol (i-propanol).



One of the major projects of the expansion of the Neodesha refinery was the erection of a new catalytic cracking unit which gives the plant a wider range of improved products.



Modernization at Neodesha also included this new boiler house with a capacity of 250,000 lb of steam per hour.

Kansas' Oldest

Neodesha Refinery Installs Modern Units

Plant was first opened in 1897 to provide refining facilities of state's first oil production, now processing 19,700 bbl daily

E. A. METCALF

ON a cold October 28, 1892, a derrick was erected at the southeast edge of Neodesha for the prospective drilling of an oil well. This well, which began to flow crude oil on November 28, was later known as the Norman No. 1. Significance of the Norman No. 1 well extended beyond the petroleum that it eventually produced. It was the first commercial well in the Mid-Continent field and led to the development of this tremendous area in Kansas, Oklahoma, and Texas. It began a new and important chapter in the history of the still young petroleum industry.

One of the results of the opening of the Mid-Continent area was the building of a refinery at Neodesha. Standard Oil Company of Kansas, whose refinery was bought by Standard of Indiana in the fall of 1932, began as a marketing company. With a source of crude close at hand the firm decided in 1897 to build a refinery to process it.

The first stakes for the Neodesha refinery were driven on February 15, 1897, and about three months later the first batch of crude oil was charged to the stills. The refinery originally consisted of two crude stills, one steam still, one agitator, one pump house, a small loading rack, a few tanks and other miscellaneous construction. All of this was on about 8½ acres of land. The process used for crude distillation was known as the "Batch System" and the products made at that time were refined oils, naphtha, and fuel oils.

Standard's Neodesha refinery expansion reveals a story of progress from a 500 bbl per day in 1897 to nearly 40 times that amount at present, or about 20,000 bbl per day, which is

EXCLUSIVE

The Author

E. A. Metcalf is manager of the Neodesha, Kansas, refinery for Standard Oil of Indiana. His first employment was in the summer of 1911, in Marietta, Ohio, when he worked as a laborer on Buckeye Pipe Line from Joy to Bremen. He went to work at the Neodesha refinery in 1913. Metcalf spent two years as an infantry lieutenant, 6th Division, World War I.

enough motor fuel to last the average motorist 1000 years.

Just as Neodesha's initial prosperity was the result of the opening of oil fields in its area, later development was influenced by the discovery of other pools. Production around Neodesha was overshadowed and it became primarily a refining center.

Today the refinery is on 200 acres of land at the edge of Neodesha. A majority of the town's families have some connection, past or present, with Standard through their immediate family, relatives or neighbors.

Because the Neodesha refinery has been owned by Standard of Indiana for just 21 years, many of its present workers began with Standard of Kansas. E. A. Metcalf, manager, has spent 40 years at the plant. He became manager in 1942 after having served previously as superintendent. H. G. Schnetzler is the plant's general superintendent.

First major expansion took place during 1903 and 1904 when the works office building was constructed, several more stills added, and electric light plant and telephone system were installed, the dam in Fall River at Neodesha was built, and several tanks were constructed in addition to the tanks already in service. A battery of new tar stills was also constructed during this period. Plant area was increased from 8 to 14 acres.

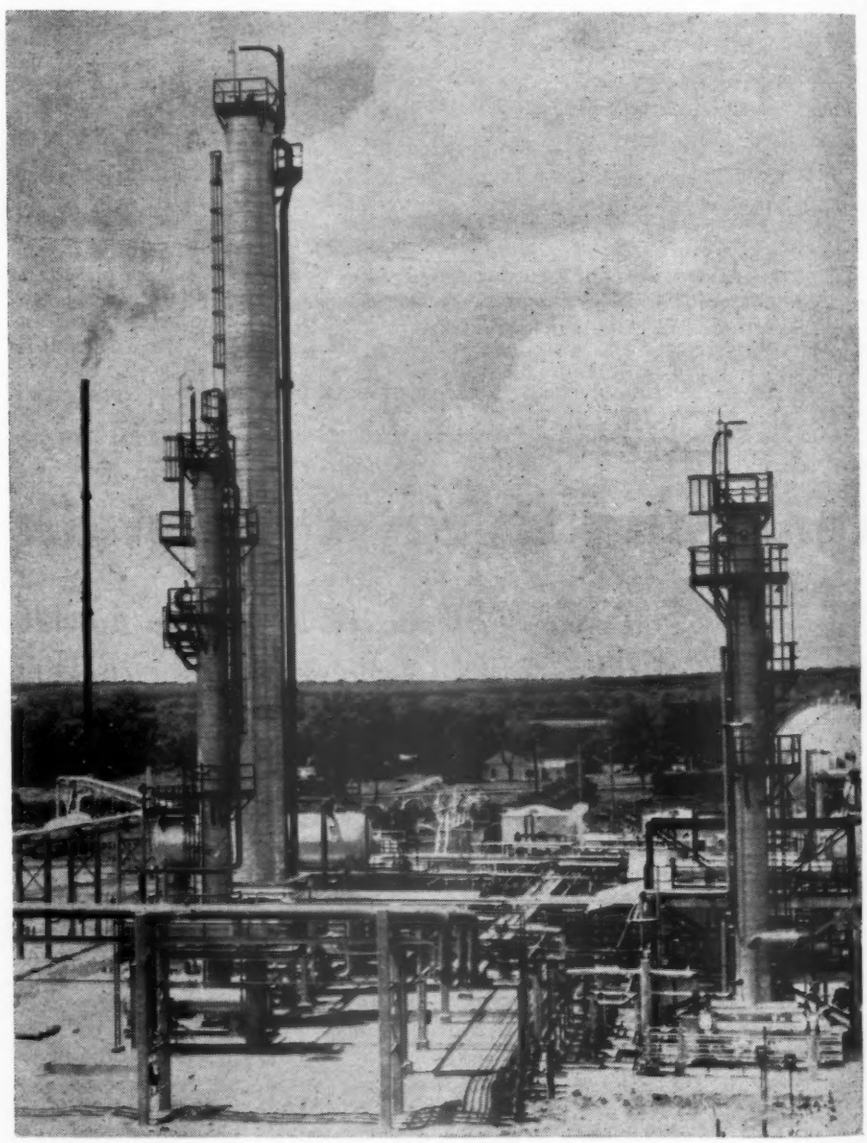
Next major expansion took place in 1914 with the erection of two batteries of crude and coke stills and 40 Burton shell pressure stills together with accessory pump houses and tankage. Acreage was increased to 56.

Another large expansion period was in the 1919-1921 period during which two batteries of atmospheric pressure stills, 20 more Burton shell stills, and 40 Burton tube stills were built. Twenty Burton tube stills had previously been built in 1916 along with a battery of crude stills. The river water station and new power plant were built, two batteries of coke stills were converted to continuous operation, and a new boiler house was built during this period.

The first Holmes-Manley unit was built in 1927. Two batteries of Burton tube stills were converted to a continuous process in 1929. The second Holmes-Manley unit, other thermal cracking facilities and a modern gas recovery plant were constructed in 1932.

Principal items of construction since the refinery was purchased by Standard of Indiana in 1932 have been extending the gas gathering system to north field crude and gasoline storage tanks, addition of refrigerated storage for light gasolines, rebuilding of the cracking unit to a two furnace unit with soaking drums in 1937, installation of turbine generator in 1940, and the addition of naphtha reformer unit, making a three furnace cracking unit in 1949.

About the middle of 1950 a study was made for expanding crude through-put of the Standard Oil Company (Indiana) refineries. One result was the decision to increase the crude running capacity of the Neodesha refinery from 10,400 bbl per day to 19,700 bbl per day and install modern facilities for product quality improvement at the higher production rate. It was decided, for the first phase of the program, to expand the crude operations as quickly as possible and transport certain unfinished stocks to the Sugar Creek refinery, which then had surplus catalytic cracking capacity for final processing. A new products pipe line between the two refineries was to be constructed to integrate their operations. Ultimate use planned for the pipe line was to transport finished products (as is now being done) for distri-



Improved facilities at Neodesha include this new sulfuric acid alkylation unit which provides high octane components for aviation gasoline and improved motor fuels.

bution in the company's pipe line system after completion of the Neodesha expansion and modernization program.

Work was begun on the design stage of this program in the fall of 1950 and construction began in January of 1951. Crude runs were increased to the desired amount in February of 1952. Principal items in connection with this project were: Rebuilding the continuous crude battery, adding stills, enlarging condensers and exchangers; using existing equipment to increase coke stills from 12 to 18 and adding three preheat stills; enlarging utilities, water and sewerage facilities; increasing capacity of gas recovery plant, gas lines and doubling gas compressor capacity; providing additional tankage, and building a new research laboratory and additional office space.

The products pipe line department constructed the new 8-in. products pipe line from the Neodesha refinery to the Sugar Creek refinery. The line is approximately 150 miles long and can handle up to 17,000 bbl per day of oil, though the average throughput will be from 10,000 to 12,000 bbl daily. The one pump station on the line is at Neodesha and is equipped with a dehydration plant. The line was completed in March 1952 and has been in satisfactory operation ever since.

Contracts were entered into with the Foster-Wheeler Corporation in May of 1951 for the construction of a catalytic cracking unit with its own vapor recovery unit, and an alkylation unit. These modern units are now in operation, completing the second phase of the latest expansion program.

The fluid catalytic cracking unit is a stacked reactor type that was designed by Foster-Wheeler. The unit was designed to charge 9000 bbl per day of gas oil and to operate at about 55 per cent conversion. Coke burning capacity is approximately 8000 lb per hour. The unit uses synthetic catalyst and operates by heat balance. The unit has two stage cyclones in the regenator and single stage cyclones in the reactor and has no Cottrell precipitator. Slurry oil from the bottom of the main fractionator is recycled to completion. A vapor recovery and product fractionation system is integral with the unit.

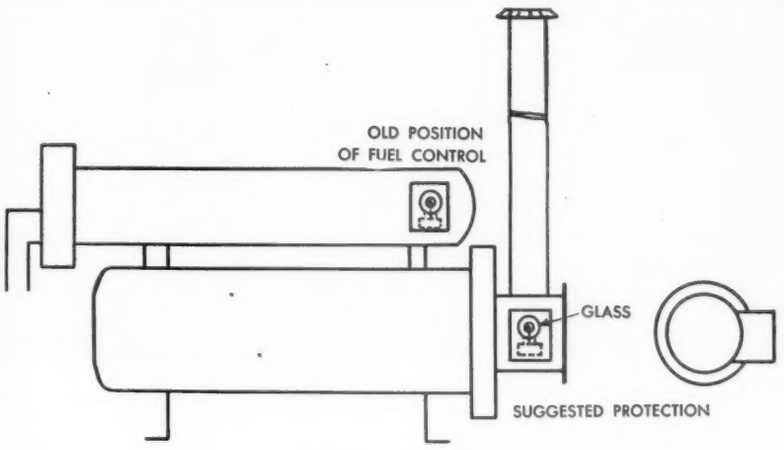
The alkylation unit was designed by Foster-Wheeler and is a sulfuric acid unit with a three stage cascade type reactor. Self refrigeration is employed using a centrifugal refrigeration compressor. This unit has a capacity of approximately 1000 bbl per day of aviation alkylate.

Modernization at Neodesha also included the addition of modern new power and steam generation facilities. Two new Babcock and Wilcox steam boilers were built. Each boiler operates at 600 lb pressure and has a capacity of 125,000 lb of steam per hour. By-product power is generated by operating two new 2500 kw turbo-generators exhausting to the 100-lb steam system. Steam for process usage is supplied to the refinery at 100 lb pressure and exhaust steam is collected and used at 10 lb pressure. Boiler feed water is treated with new hot lime-zeolite facilities to zero hardness.

Due to this expansion in operating facilities of the Neodesha refinery, the number of employees increased from 200 to approximately 475. The present payrolls exceed $2,125,000 per annum. This material increase in employment and payroll is a big boost to the economic life of the community. It means more purchasing power in Neodesha and the surrounding area. In turn the expansion affects others who are partly or entirely dependent on refinery operation for work.

Improved facilities at Neodesha provide high octane components for aviation gasoline and improved motor fuels. The expansion also provides the modern equipment needed to produce products competitively and establishes a products pipe line network that makes it possible to send these products economically into the areas where demand is greatest. * * *

PLANT AIDS



Protected heater fuel control.

Protected Heater Fuel Control[1]

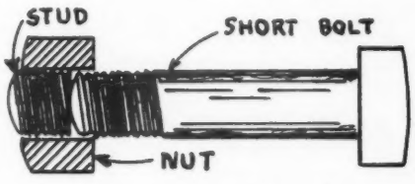
Z. C. BENNETT[2]

The purpose is to prevent the freezing of heater fuel controls. In this installation the fuel control pilot was originally mounted on the side of the top drum of an insulated steam heater operating at 275 psi. In freezing weather the condensed steam in the bourdon tube of the pilot and the pressure gage would freeze, damaging the controls, and either causing the burner to go out or fail to shut off and blow the soft plug. The pilot control and pressure gage were moved and mounted on the heater stack breeching. A metal box with removable cover was attached to the breeching and enclosing the controls. The rim and glass from a 6-in. pressure gage was installed in the front cover of the box for viewing the steam pressure gage without removing the cover. During hot weather the cover is left off the box. Since this installation was made three winters ago, no freezing of controls has occurred.

[1]Class A, honorable mention, NGAA Kinks Contest.
[2]Continental Oil Company, Basile, Louisiana.

"Cover Up" Bolt Trick

As a reader of this publication you have doubtless had numerous experiences with bolts. But, have you ever seen a "cover up" bolt job as shown in the accompanying rough sketch? It is all right to know what constitutes a good bolt, but it is also well to know why structures sometimes fail—because of



the possibility of a poor bolt like this. On many occasions this writer has been criticized because he insists on writing about failures as well as successes. He maintains that readers should know about "cover up" tricks, such as this one.

Workers will commonly "cover up" poor work, if possible, rather than do it over again in order to do the job right. This sketch shows an example that was brought to this writer's attention recently. The worker inserted a bolt that was too short. He didn't want to go to the trouble of removing the bolt and inserting a longer one, so, he cut off a threaded piece the writer has called a "stud" and inserted it. This particular job was of sufficient importance to require an inspector. The inspector came, gave his official nod of approval, and passed along to his next inspection job. Had the inspector known about tricks like this he probably would have caught it.—WFS.

FIG. 1. Apparatus employed for carrying out Bureau of Mines routine crude analysis method.

Crude Oil Characterization by the Bureau of Mines Routine Method

This method has been employed to analyze and to study thousands of samples of crude; serves as a universal "yardstick" for crude properties

H. M. SMITH and JOHN S. BALL

SEVERAL thousand crude oil samples have been analyzed over the past 35 years by the Bureau of Mines, using its routine method. Because these analyses have been made on a comparable basis, they form an invaluable store of information concerning the differences in petroleums produced in this country during that period. They also serve as a reference basis for comparison with newly discovered crude oils, so that the latter may be classified as to possible methods of utilization.

The routine method of analysis was developed by the Bureau of Mines in the period 1915-20,[2] and since that time only minor changes have been incorporated. Over the years some tests have been added, and the form of presentation is slightly different, but the early analyses can be compared with the more modern ones. Both American and foreign oils have been analyzed. A bibliography of published analyses has been prepared.[5]

The apparatus used in the analyses is shown in Fig. 1. An outline of the procedure followed[5] is shown in Fig. 2, and a sample of the finished analysis is shown as Table 1. These analyses are carried out at both the Petroleum Experiment Station, Bartlesville, Oklahoma, and the Petroleum and Oil-Shale Experiment Station, Laramie, Wyoming. At the latter location, it is necessary to use apparatus[6] pressured to 760 mm of mercury pressure to obtain results comparable to those obtained by sea-level laboratories.

The analyses are used by crude-oil producers, petroleum engineers, petroleum geologists, prospective buyers of oil, petroleum chemists and refiners, and manufacturers of special petroleum products. They have been used to compare oils as to possible origin, utilization, and valuation.

The correlation index (C. I.) has been developed[4] for ease in comparing analyses performed by the routine method. The index is based on specific gravity

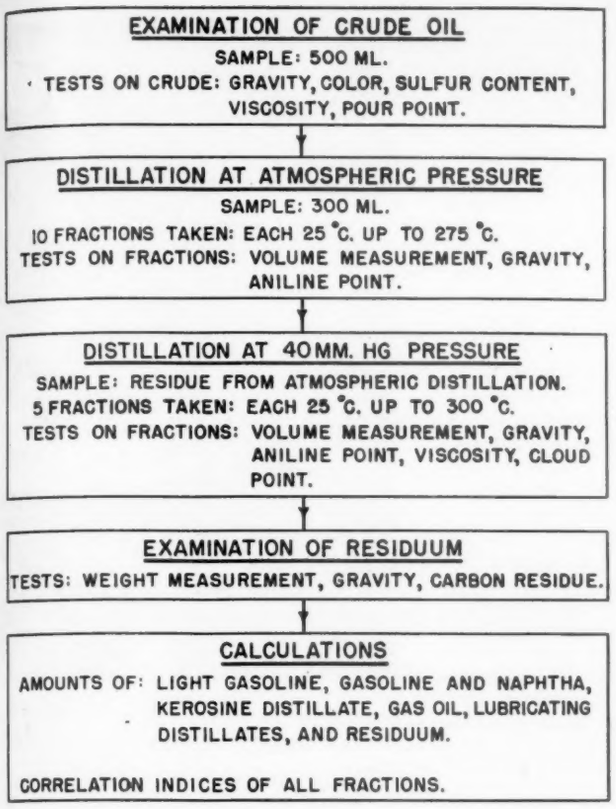

EXAMINATION OF CRUDE OIL
SAMPLE: 500 ML.
TESTS ON CRUDE: GRAVITY, COLOR, SULFUR CONTENT, VISCOSITY, POUR POINT.
DISTILLATION AT ATMOSPHERIC PRESSURE
SAMPLE: 300 ML.
10 FRACTIONS TAKEN: EACH 25 °C. UP TO 275 °C.
TESTS ON FRACTIONS: VOLUME MEASUREMENT, GRAVITY, ANILINE POINT.
DISTILLATION AT 40 MM. HG PRESSURE
SAMPLE: RESIDUE FROM ATMOSPHERIC DISTILLATION.
5 FRACTIONS TAKEN: EACH 25 °C. UP TO 300 °C.
TESTS ON FRACTIONS: VOLUME MEASUREMENT, GRAVITY, ANILINE POINT, VISCOSITY, CLOUD POINT.
EXAMINATION OF RESIDUUM
TESTS: WEIGHT MEASUREMENT, GRAVITY, CARBON RESIDUE.
CALCULATIONS
AMOUNTS OF: LIGHT GASOLINE, GASOLINE AND NAPHTHA, KEROSINE DISTILLATE, GAS OIL, LUBRICATING DISTILLATES, AND RESIDUUM.
CORRELATION INDICES OF ALL FRACTIONS.

FIG. 2. Standard procedure employed in making analyses.

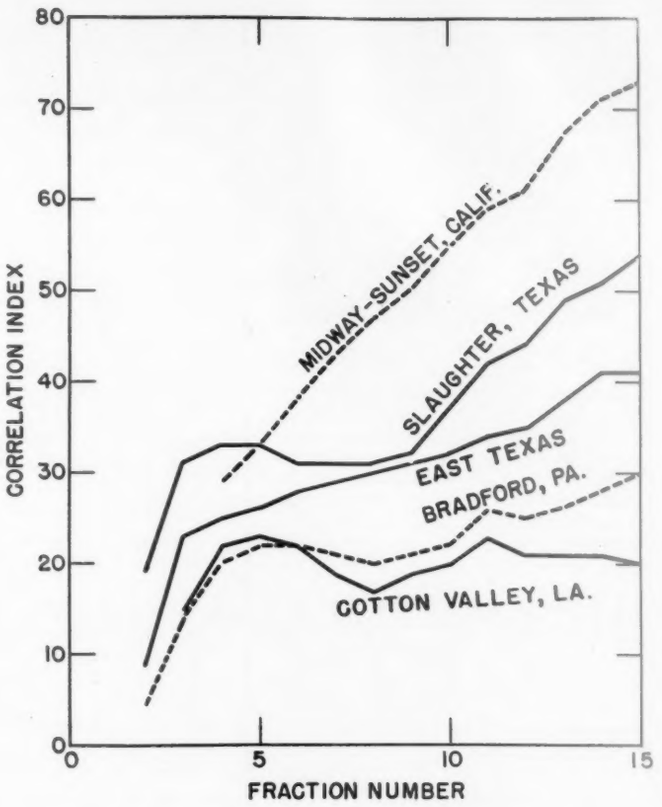


FIG. 3. Correlation index patterns for various crude petroleums.

and boiling point and in a general way indicates composition. Thus, straight-chain paraffins have a correlation index of 0; branched-chain paraffins, values from 1 to 10 or 12; cyclopentanes and cyclohexanes (naphthenes), values from 50 for the first members of the series to 12 or 14 for the C_{20} members; monocyclic aromatics or alkylbenzenes, from 100 for benzene to about 26 for C_{20} alkylbenzenes; dicyclic naphthenes or decalins, from 73 for cis-decalin to 54 for n-butyl decalin; dicyclic aromatics or naphthalenes, from 120 for methylnaphthalene to 90 for l-butylnaphthalene. Thus, it is evident that low index values indicate paraffinicity and saturation in ring structures. Unsaturation in ring structure increases the index as does ring fusion. Most fractions of crude oil fall between 0 and 100 index numbers, and the values for various fractions of a single crude oil may differ widely, as some oils are paraffinic in a certain boiling range and may contain various types of ring structures in others. A plot of the C. I. values for the 15 fractions from a crude-oil analysis gives a C. I. pattern that may be characteristic of oils from a given environment. C. I. patterns for several representative oils are shown in Fig. 3.

The correlation index values have been used to determine the formations in a field from which a certain well is

TABLE 1. Analysis of East Texas crude oil.

East Texas field Woodbine sand, Upper Cretaceous	Sample 45035	Texas Rusk, Cherokee, Gregg, Smith, and Upshur Counties

General Characteristics

Specific gravity, 0.836 — API gravity, 37.8 deg
Sulfur, per cent, 0.36 — Color, brownish black
Saybolt Universal viscosity at 100 F, 44 sec.

Distillation, Bureau of Mines routine method.

Distillation at atmospheric pressure, 749 mm. First drop, 25 C (77 F)

Fraction number	Cut at deg C	Cut at deg F	Per cent	Sum, per cent	Specific gravity, 60/60 F	Deg API, 60 F	C. I.	Aniline point, deg C	S. U. viscosity, 100 F	Cloud test, deg F
1	50	122	3.0	3.0	0.638	90.3	—			
2	75	167	5.0	8.0	.673	78.8	8.9			
3	100	212	4.5	12.5	.723	64.2	23			
4	125	257	7.0	19.5	.745	58.2	25			
5	150	302	5.4	24.9	.765	53.5	26			
6	175	347	5.1	30.0	.784	49.0	28			
7	200	392	4.3	34.3	.798	45.8	29			
8	225	437	4.4	38.7	.812	42.8	30	60.4		
9	250	482	5.6	44.3	.827	39.6	31	65.0		
10	275	527	6.1	50.4	.838	37.4	32	70.0		
Distillation continued at 40 mm.										
11	200	392	3.3	53.7	0.851	34.8	34	74.2	41	20
12	225	437	6.1	59.8	.861	32.8	35		45	40
13	250	482	5.8	65.6	.875	30.2	38		57	60
14	275	527	4.9	70.5	.888	27.9	41		83	80
15	300	572	5.3	75.8	.894	26.8	41		155	98
Residuum			22.8	98.6	0.966	15.0				

Carbon residue of residuum, 10.0 per cent; carbon residue of crude, 2.3 per cent.

Approximate Summary

	Per cent	Specific gravity	Deg API	Viscosity
Light gasoline	12.5	0.683	75.7	
Total gasoline and naphtha	34.3	0.738	60.2	
Kerosine distillate	4.4	.812	42.8	
Gas oil	20.7	.843	36.4	
Nonviscous lubricating distillate	9.9	.867–.890	31.7–27.5	50–100
Medium lubricating distillate	6.5	.890–.897	27.5–26.3	100–200
Viscous lubricating distillate	—	—	—	Above 200
Residuum	22.8	.966	15.0	
Distillation loss	1.4			

The Authors

H. M. Smith

J. S. Ball

Harold M. Smith has been with the Petroleum Division, Bureau of Mines, for nearly a third of a century, where he has been pioneer and leader in his field on many activities. He is director of American Petroleum Institute Research Project No. 48A, identifying petroleum sulfur compounds, and is and has been for many years Chief of the Chemistry and Refining Branch of his Experiment Station, headquarters for the petroleum work of the Bureau. Smith is active in several technical and scientific bodies, member of American Chemical Society since 1924, member and officer of Committee D-2 of ASTM; member also of API and of the Oklahoma Academy of Science. He is a native Rhode Islander, M.S. graduate of Clark University, and has been with the Bureau since 1923.

John S. Ball is presently in charge of work on petroleum chemistry and refining and shale-oil composition at the Petroleum and Oil-Shale Experiment Station of the Bureau of Mines at Laramie, Wyoming. A native of Texas, he was graduated from Texas Technological College and did further work at the University of Colorado. Starting with the Bureau of Mines in 1938 as a junior engineer, he has been advanced to his present position. He is also associate director of API Research Project 48A on sulfur compounds of petroleum, and is working on the organization of API Project 52 on the nitrogen compounds of petroleum, a project due to be activated in July.

producing. They have also been used to suggest origins of oils that have migrated. They can be used to evaluate oils for special purposes, such as usefulness in the preparation of aviation base stock or in the content of toluene. If the aromatic content is known, by means of a simple correction the correlation index can be used to estimate the content of naphthene rings in the fraction.[3] Examples of its use for comparing oils from a given geographical area in relation to geological producing horizons are given in a paper on Wyoming crude oils.[1]

Valuation of an oil from the Bureau of Mines analysis can only be obtained through a comparison of similar crude oils whose refining characteristics are known. Inasmuch as refinery yields vary considerably depending on the equipment used, each refiner must necessarily make his own estimations. The Bureau analyses, however, prove valuable in giving a screening test to indicate similarities and differences of a new oil to those which have been processed previously.

The series of articles, of which this is the first, will describe oil from some of the newly discovered fields and indicate how they compare in properties with previously known oils. Some possibilities of utilization will be discussed, based on the Bureau of Mines routine analyses. The first article in the series will discuss oils from that part of the Williston Basin in Montana and North Dakota.

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★ ★ ★

Salvaging Welded Pipe Connections

RICHARD SNEDDON

Although he is a native of Minnesota and has a thoroughly Hibernian moniker, Harvey T. Dennis, Welder A at General Petroleum Corporation's Torrance refinery, displays all the attributes of a Scottish mechanic. At least, he hates waste, and he has the native engineering skill to do something about it. Hence the simple but ingenious device which he fashioned from a bit of pipe, an old flange, some steel plate, and a Model T spindle. These he has assembled into a turntable that is operated at any desired speed by means of a radiograph machine, and he is thus enabled to perform salvaging operations on a variety of welded pipe connections, with an oxy-acetylene cutting torch, in a mere fraction of the time that was formerly required to do the job on a lathe. As a matter of fact, the time and expense of machining was usually prohibitive, and when valuable fittings had to be taken out along with defective pipe, they simply had to be discarded.

With a helical lifter to elevate the cutter head to any level, and a carriage to provide horizontal adjustment of the work piece, Dennis can cut down to its components anything from 1½-in. to 12-in. welded flanges. He has even cut out a 24-in. weld-neck in the short space of 1 hour, an operation that would probably take 8 hours to machine.

The process is simple but effective. A slip-on flange, for example, which has two welds, is attached to the rotary table face down, and the cutter head is adjusted to the proper position to cut through the top weld. (The machine is equipped with a series of cutter heads to take care of all angularities from 5 deg to 75 deg.) After the top weld has been cut through, the job is turned over and the under weld is cut. For this the flame is directed almost perpendicularly into the interior of the flange. When the inner or lower weld has been removed, the flange and nipple fall apart.

Weld-necks require one cut only, but the procedure is exactly the same as in the first stage of the slip-on separation. The important thing is to direct the cutter flame on the weld at the proper angle. When, in either case, the operation has been completed, the flange is ordinarily in good shape and needs very little further treatment to make it serviceable again. With the recovery of tube turns, as illustrated, the process is also similar. The problem is merely one of setting the job correctly on the rotary table, adjusting the cutter head, and controlling the speed of rotation.

Harvey T. Dennis, a welder at General Petrole Corporation's Torrance, California, refinery.

A comparison of the time required by the Dennis salvaging unit and the former manner of machining will be of interest:

Unit	*Torch-Cut*	*Machined*
10-inch weld-neck	4½ min	1 hr 20 min
12-inch slip-on	24 min	3 hr
24-inch weld-neck	1 hr	8 hr

And on small stuff, some conception of speed may be acquired from the fact that on 1½-in. weld-necks, the flanges are recovered at the rate of approximately 30 an hour.

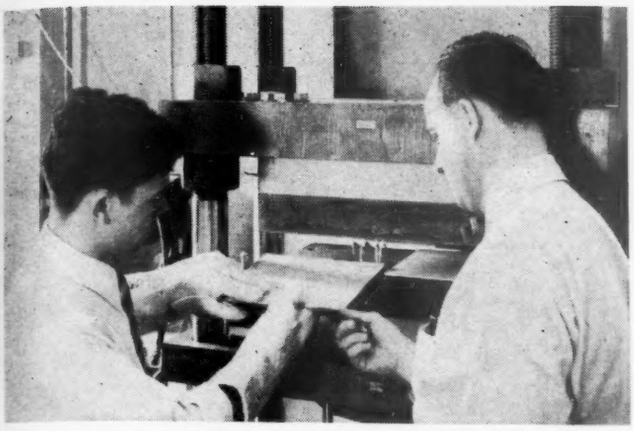


FIG. 1. Laminate is prepared prior to testing engineering properties by student workers.

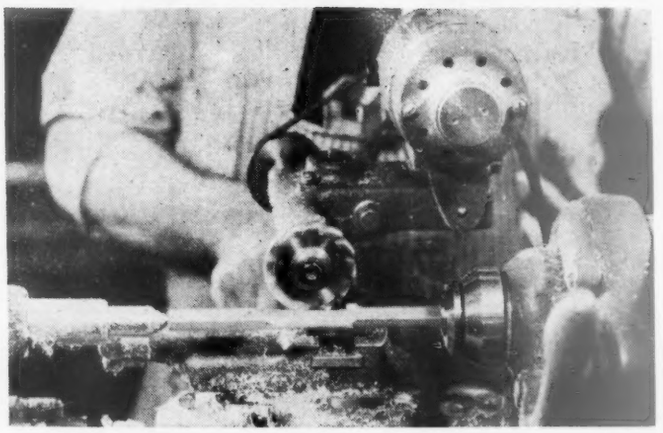


FIG. 2. Tensile test specimens must be prepared for universal plastics testing machine.

Research in Industrial Properties of Plastics

New materials for pipes, tanks, valves tested for petroleum and petrochemical industries in unique laboratory

ALBERT G. H. DIETZ*

PLASTICS research at the Massachusetts Institute of Technology is directed toward answering some of the questions about the combination of elastic and plastic behavior found in plastics when they are under load. Theories and engineering design methods applicable to materials like steel and concrete are not necessarily applicable to plastics, and new aproaches must be found if plastics are to be used satisfactorily in all sorts of engineering and non-engineering applications. Consequently, the long-range program was set up by the Plastics Materials Manufacturer's Association, now operating as a group in the Manufacturing Chemists' Association. Other interested industrial concerns also participate in the program.

Applications in Petroleum

Plastics are employed in the petroleum industry in a variety of ways, many of them involving plastics under load. One obvious application is plastics pipe. The corrosion-resistance and general inertness to chemical attack exhibited by many plastics recommend their use as pipe. Frequently the fluid petroleum product is under pressure, or under combined pressure and elevated temperature. An engineer must therefore know how the plastic will behave under continuous load, that is, the creep characteristics under the pressure-temperature conditions imposed. Is there an way in which these can be computed, and are there any supporting data? If a surge occurs in a line, how may the pipe be expected to react? How tough is the material? If a plastic tank is used, what should be its dimensions and wall thicknesses to handle the pressures? What kinds of stresses may be imposed on plastic membranes? What about valves? How can a fabricator determine if a part is sound? These and many other questions must be answered.

One of the valuable by-products of a program such as this is the education of future engineers. Graduate research leads to Doctor's dissertations and Masters' theses stemming from this project. Undergraduates carry on Bachelor's theses, and classroom work at both undergraduate and graduate level benefits from the research results. Students with a variety of backgrounds — mechanical engineering, chemical engineering, chemistry, building and architecture, civil engineering, general engineering — have participated in and benefitted from the program. Many problems remain to be solved, and long-range continuing research is needed. (Fig. 1).

Program

The goal of this plastics research project is to define the behavior of plastics under mechanical load; to predict, if possible, their behavior under a wide variety of conditions of stress, strain, temperature, and periods of time; and to show the influence of such factors as molecular weight, plasticizer, and other factors entering into the composition of the material.

The steps in the program are:

1. *Testing a typical class of plastic materials with various molecular weights, plasticizer contents, and degrees of crosslinkage, under a wide variety of testing speeds and temperatures. (Fig. 2).*
2. *Expressing the experimental data in generalized mathematical form.*
3. *Using these generalized expressions as a basis for testing other plastics to see if the expressions are valid for other polymers.*
4. *Selecting, from these experimental findings and the generalized mathematical expressions, the key tests needed to evaluate the mechanical properties of plastics and to predict their behavior under specified conditions.*
5. *Developing the broad description of plastics behavior under load, and formulating an engineering approach to their design and utilization.*

Original work under this program

*Professor of Building Engineering and Construction; Director of Plastics Research Laboratory, Massachusetts Institute of Technology, Cambridge, Massachusetts.

EXCLUSIVE

was done with methyl methacrylate, chosen in collaboration with the technical committee of the sponsoring group, because its composition could be varied over a wide range and would therefore provide a broad range of mechanical properties.

These materials have been studied in a large number of tests to determine stress-strain relationships under conditions of very slow to very fast load and strain application, creep, relaxation, and low to high temperatures. The tests, in turn, have led to the search for relationships that can be used to represent the generalized behavior of plastics as affected by composition, type of load, rate of load, and temperature.

The work has gone in two principal directions: (1) the development of the simplest possible empirical equations for easiest use by engineers, and (2) the development of more rigorous theoretical equations of greatest possible applicability but of greater complexity. The latter direction has proved to be more useful and is being pursued in the continuing program.

Subsequent to the work with methacrylate, further investigation has been undertaken with polyvinyl chloride, polyethylene, and several others, to see to what extent the generalized equations can be applied, and to what extent they must be modified to fit the peculiarities of each type of plastic. So far, the results have been quite encouraging, and it appears to be possible to correlate the behavior of these plastics under slow to rapid loading as well as in creep and relaxation on the basis of a single fundamental mathematical relationship. This relationship takes into account the combined elastic and plastic behavior characteristic of plastics materials.

Much work remains to be done, not only in this project but by the makers of the various plastics, before the ultimate goal is achieved, but good progress has been made.

FIG. 3. Test specimen undergoing flexual test run; results are recorded on continuous chart.

Testing Equipment

Before the testing program could be undertaken it was necessary to develop testing equipment, because the equipment had to be of a type that would apply the tests and record the results in terms of the plastic-elastic behavior of the materials.

The most concrete results achieved so far have stemmed from this early developmental work. The first accomplishment was the design and construction of a Universal Plastics Testing machine embodying principles of servomechanism controls which made it possible to apply predetermined rates of load and strain, a factor of considerable importance in work with plastics. These principles of control have since been incorporated into a number of commercial machines. (Fig. 3).

A second development, considered by leaders in plastics research to be at least as important as the testing machine, was the design and construction of a simple wheel-type extensometer making possible not only the measurement of true strain but the simultaneous control, by the same extensometer, of the operation of the machine at desired rates of true strain. This is of particular importance in materials which stretch a large distance and in which the tendency to creep is pronounced. (Fig. 4).

Impact

When materials of all kinds are suddenly loaded, their behavior may be quite different than when the load is more gradually applied. In a closely related program sponsored by Army

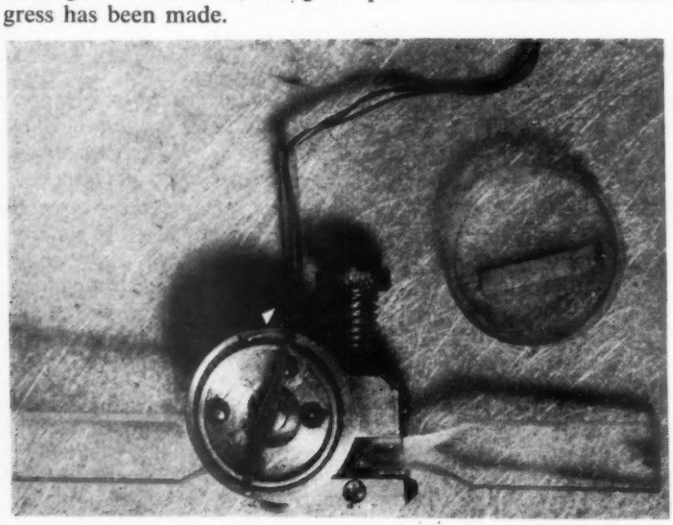


FIG. 4. This simple, MIT-designed, wheel-type extensometer brings modern concepts of measuring true strain into laboratories.

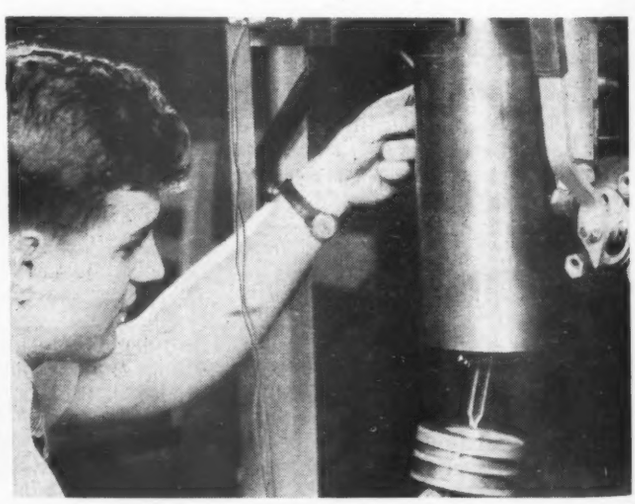
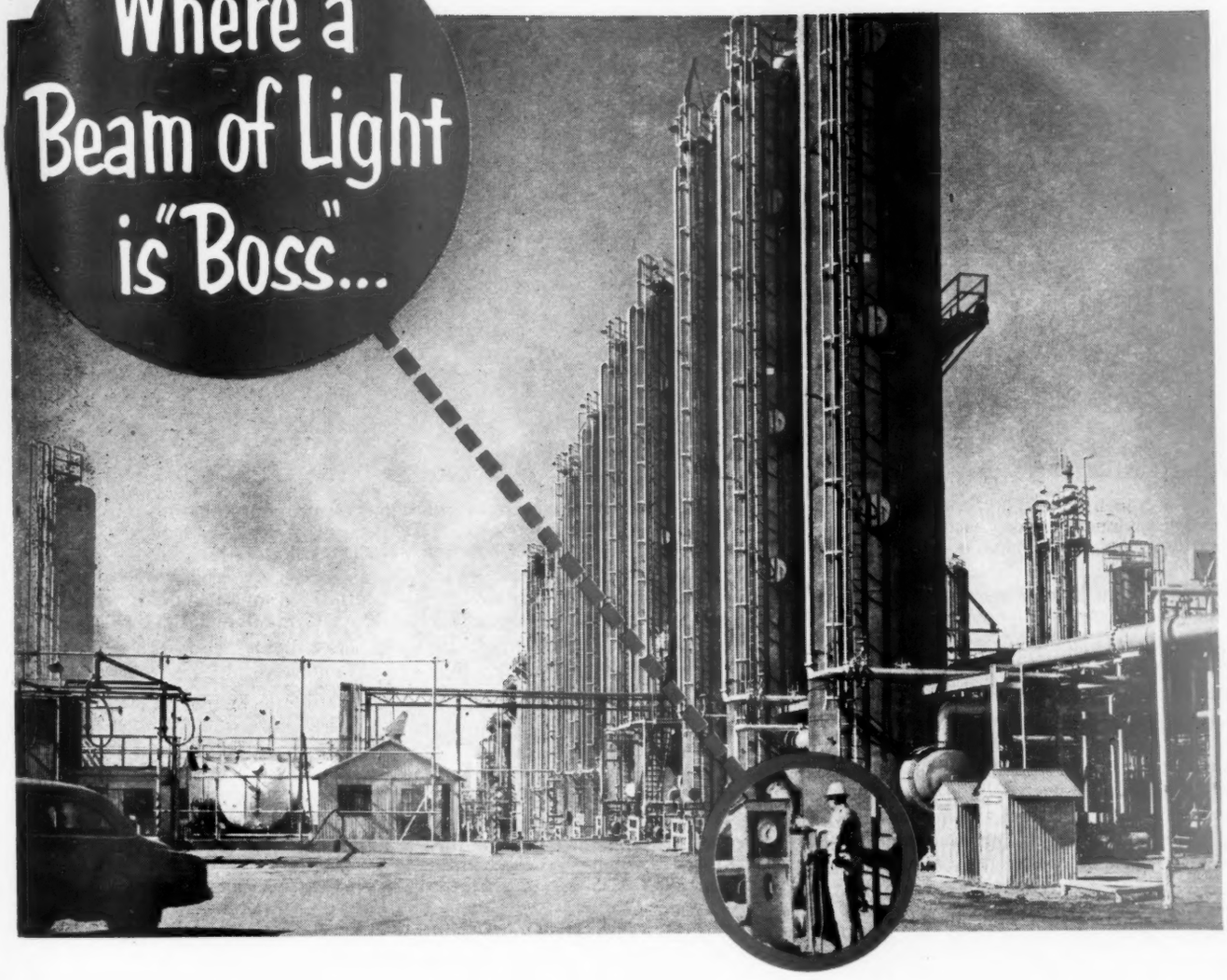


FIG. 5. High pressure gas in impact test fractures plastic being placed here in cylinder.

Where a Beam of Light is "Boss"...



Specified purity, uniformity and maximum output are maintained *automatically* on the cyclohexane column, above, by a Phillips Automatic Differential Refractometer (shown in red circle).

After years of research, development and full-scale evaluation in refinery and chemical processing, two new automatic control instruments are ready for sale or lease.

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FIG. 6. Toughness of film is recorded by photographing and timing instant of fracture; photos are made at 1/3000 sec.

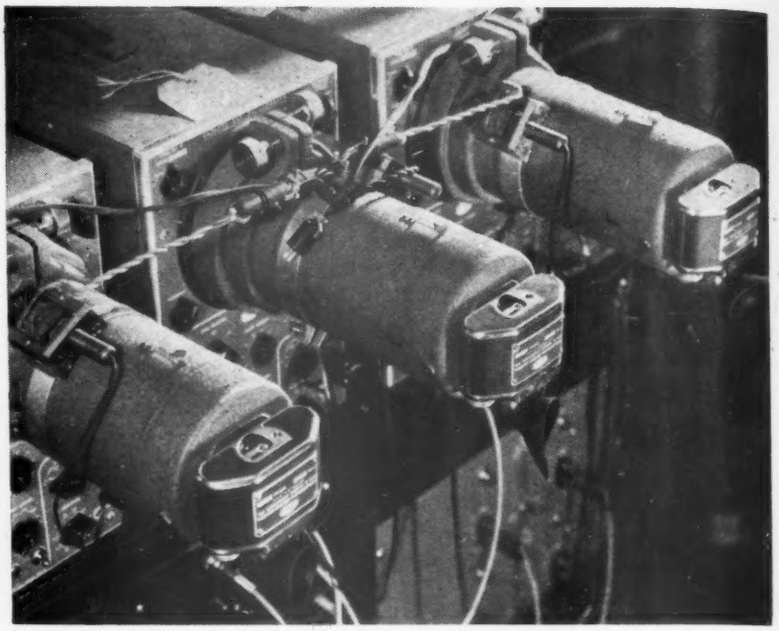


FIG. 7. Oscilloscopes keep continuous record of resistance to impact and fractures.

Ordnance, the behavior of plastics and related materials under suddenly applied loads, usually called impact, is being studied. In an air-actuated cylinder a specimen can be loaded to failure in a matter of a few thousandths of a second, and its stress-strain behavior recorded on a battery of oscilloscopes. The results, when correlated with the slower tests carried out on the testing machine, help to extend the experimental verification of the theory of plastic-elastic behavior, and reveal any changes which may occur in the properties of plastics when loads are suddenly applied. (Figs. 5, 7).

Film

Plastics films are employed in a large number of different applications for which their toughness recommends them. Toughness is a rather vaguely defined property which seems to be most usefully measured by ability to absorb energy. A film evaluation program is accordingly underway in which energy absorbed, as measured by stress-strain records, is being determined on a variety of plastics films. Because energy absorption may be different in different films at different speeds, tests are being conducted over a large range of rates, from very slow to very fast. (Fig. 6).

Measurement of Cure

One of the problems facing the molder of thermosetting plastics is to follow the progress of cure in the mold while the material is under elevated heat and pressure. A method of following cure has been devised in which short bursts of high-frequency sound (several million cycles per second) are passed through the material by means of crystal transducers built into the mold. It has been found that the transmission of the sound waves is markedly changed as the plastic cures, so that progress of cure can be followed by noting the changes in the transmitted pulses.

The same equipment has been used in a preliminary way to study the soundness of plastics parts. If voids or other unsound spots are present the transmitted pulse should be different than in sound material. This work is still in progress. (Fig. 6).

As more results are forthcoming, as experience is gained in their application, and as more engineers are trained in plastics and become familiar with their characteristics, the field of plastics engineering should advance, and the materials should find their place with other materials of engineering. ★ ★ ★

PLANT AID

Shop Plug Valve Grinder[11]

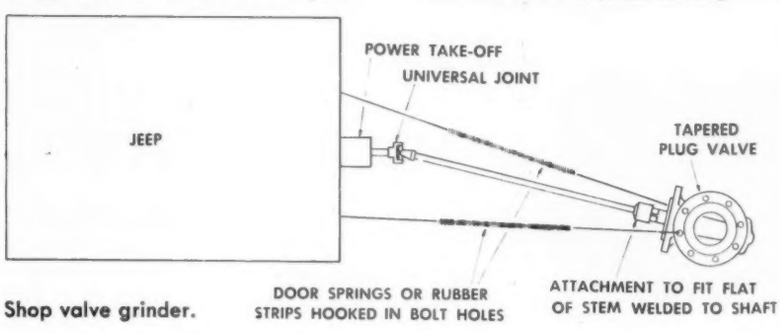
W. B. BOWEN[##]

A jeep, tractor, or other vehicle with power take off is required. Come off the shaft of the power take off with a universal to this, attach a shaft about 36-in. in length, of 1-in. pipe, ¾-in. rod, or anything of sufficient strength. On the end of this shaft, weld a block or square to fit the flat on the stem of the valves to be ground, slip flat of valve core stem into this fitting. Get two strips of inner tube rubber 3 in. wide and 18 in. long and attach a wire hook to each end of each strip, lay valve body on its side directly behind power take off shaft, put compound on valve core and slide valve body forward onto core, hook the rubber strips one on each side of power take off, hook the other ends, one on each side, into the first holes below center in the main flanges of the valve body. Rotate the power take off in low gear for about one minute then in reverse for the same length of time. When core is removed for compound a file on the high places may be used to good advantage.

No brace will be required to keep valve body from turning on floor if compound is kept on core and proper tension is maintained but as a safety factor it can easily be added.

##Panoma Corporation, Guymon, Oklahoma.

[11]Class D, first and grand prize, NGAA—Panhandle-Plains Regional Meeting.



Shop valve grinder.

Savings Effected by Precooling Engine Combustion Air†

Fuel consumption, maintenance, and capital cost reduced in gas and diesel engine use

W. R. CROOKS*

If in the highly competitive process of supplying members of this group with services as well as material things such as engines and compressor equipment, we have not won, and retained a mutual respect and even admiration, we have failed to a very great degree. Business, as we in this country know it, would lose its zest and I believe that our great incentive to excel would diminish and we would deteriorate both individually and nationally.

The subject of this paper, "The Effects of Precooling Combustion Air for Gas and Diesel Engine" seems timely for it is one very effective means of reducing specific fuel consumption, maintenance, and the capital cost of power and compressor plants. These items all add up to an appreciable amount, since from 1948 to date, the spark ignited gas engine has been developed sufficiently to deliver 60 per cent more power from one cubic foot of gas, and the load pulling ability has been increased 100 per cent without changing the cylinder bore size or the speed.

It seemed desirable to divide this paper into three broad sections.

1. What changes have been taking place to make combustion air conditioning profitable?
2. Various methods of combustion air conditioning.
3. Specific gains and possible engine plant adaptations resulting from or aided by the use of combustion air conditioning.

What changes have been taking place to make combustion air conditioning profitable? The internal combustion engine began its rise to prominence just 75 years ago when the otto cycle engine was developed. This development gave us the compression of the gaseous mixture before combustion, with the resultant increase in pulling ability and efficiency. The crankshaft and connecting rod as we know them today were incorporated into this development.

By the turn of the century many companies were manufacturing internal combustion engines, and they were displacing steam engines on smaller jobs. The Bessemer Gas Engine Company, now a part of the Cooper-Bessemer Corporation, actually started in business by supplying 2-cycle cylinders, clutches, and necessary parts to convert steam engines into 2-cycle gas engines.

The C. and G. Cooper Company, now a part of the Cooper-Bessemer Corporation, manufacturers of engines since 1853, had developed a large double acting 4-cycle gas engine, and by 1910 had established the same degree of reliability as the large Corliss steam engine plants. Thermal efficiency of this engine was exceptionally good being about 25 per cent. The BMEP rating was about 65, and these values remained practically unsurpassed for 35 years.

The diesel engine was in commercial production in this country before 1904 with an engine in operation at the St. Louis World's Fair. The rapid growth of diesel engine industry began with the expiration of Dr. Diesel's patent in about 1915.

Once the principles were established, and engines were in operation, refinements were slow. Combustion characters were studied, with the resultant understanding of combustion chamber shapes and flame front travel. It was quickly learned in combustion studies that too rapid burning produced a rough running engine or detonation. The bearings were improved, the rotating weights were reduced permitting higher rotative speeds, but the BMEP and efficiency remained almost constant. It seemed after 35 years of effort that the efficiency of gas engines would remain at 9500 Btu—which is 27 per cent thermal efficiency—and the pulling ability at around 70 BMEP for 4-cycle, and 60 BMEP for 2-cycle engines.

It had long been known that the theoretical requirements for complete combustion of one cubic foot of gas having a heat content of 1000 Btu per cubic foot is approximately 10 cu ft of air. This gave maximum power. Maximum economy required slightly more air but at the sacrifice of pulling ability. This fuel-air ratio had a self ignition point of approximately 325 F. Low self-ignition temperature naturally limits compression temperatures and seemed to be an inherent limitation to gas burning engines.

Discovery of a means of raising the self-ignition temperature of a combustible mixture of gas and air broke the 35-year dead lock on limitation of efficiencies and pulling ability of gas engines, and within three years after that date spark ignited gas burning engines with almost 40 per cent thermal efficiency and 125 BMEP were in successful operation. The self-ignition temperature was raised from compression pressures slightly above 100 psig to at least 600 psig by changing the gas-air ratio from 1 to 10 to 1 to 17. The low ratio of 1 to 17 is near the detonation limit and point of maximum economy. The high ratio of approximately 1 to 30 is as lean a mixture as will support combustion. This immediately opened the way to supercharging gas engines by mechanical means or by turbochargers, and it is by this method that the ratings have been increased so appreciably.

Pressure charging immediately imposes an additional heat load in the compression cycle of operation. In 1936 when we began turbocharging 4-cycle engines, the inlet manifold pressure was increased to 5 in. Hg. probably increasing the air temperature 30 F. Improvements in turbochargers have made it economical to charge the inlet manifold to 25 in. Hg. with a resultant increase in temperature of 150 degrees. We are using a supercharging pressure of 12 in. on gas engines and will undoubtedly go higher.

Engine manufacturers have long known the advantage of having relatively cool combustion air. however, it has not always been economically justifiable. We tried it in 1940 and found some gain, but it was cheaper to keep the engine ratings down rather than condition the combustion air. In 1946 we tried it again with the same results. In 1948 we ran a new series of tests and this time found it economically justifiable. We have continually been increasing the use of combustion air conditioning equipment since that date. Why is it economical to condition combustion air now and not a few years ago?

a. Load pulling ability has been raised as much as 100 per cent.

b. Compression pressure on gas burning engines has been increased up to 6 times former practice.

c. We have increased our jacket water

†Presented before Natural Gasoline Association of America, Permian Basin Regional Meeting, 1953, under the title "The Effect of Precooling Combustion Air for Gas and Diesel Engines."

*Cooper-Bessemer Corporation

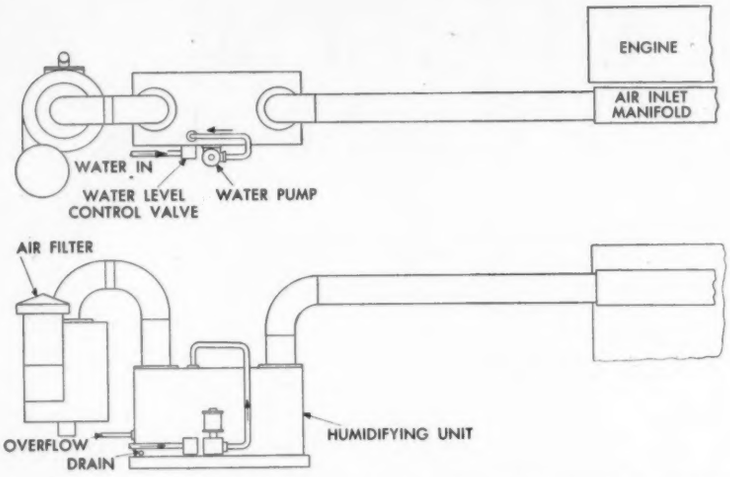


FIG. 1. SIMPLE combustion air conditioning system for atmospheric engines.

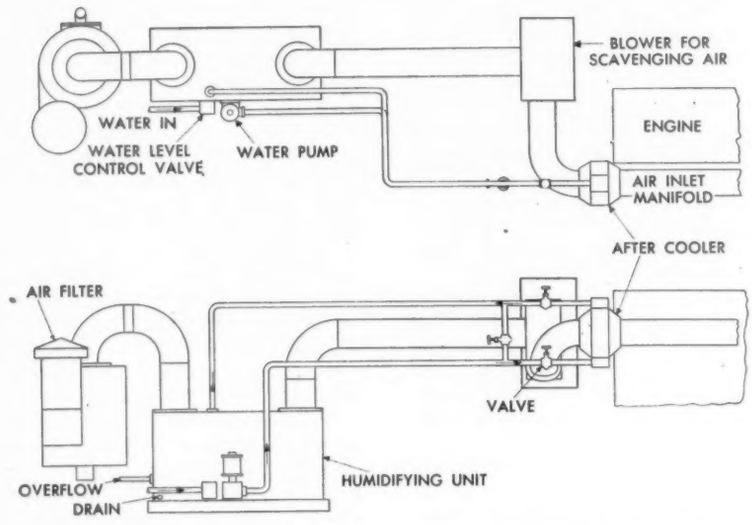


FIG. 2. TYPICAL air-cooling system for 2-cycle pressure-charged engines.

and lubricating oil temperatures thus improving performance and reducing maintenance.

d. The supercharger and even scavenging air pressures have been raised, resulting in increased temperatures of the combustion air.

Various methods of combustion air conditioning. We are using the term "combustion air conditioning" as meaning preparation of the air entering the cylinder being in the best condition to promote orderly combustion. Cooling does the following:

a. Increases the density, thus making more oxygen available for combustion.

b. Cools the internal surfaces of the cylinder; this is especially significant for 2-cycle engines, and 4-cycle supercharged engines, as cool air is flushed through the cylinder.

c. Reduces the final compression temperature.

Humidifying the air tends to aid combustion by causing a more orderly flame propagation, thus reducing combustion noise. If we not only cool the air, but also humidify it, we can then say that we truly have a combustion air conditioning system.

Cooling the combustion air can be successfully accomplished in several ways, the real problem being to find the most economical method. Let us have a look at the cooling requirements for a 2-cycle engine under typical conditions of 100 F ambient.

Temperature of the combustion air at the intake ports after compression and after pick-up of heat from

Cylinder surfaces	150 F
Approximate weight of air per hp/hr	15 lb
Wet bulb temperature	84 F
Approximate weight of air for 1000 hp engine	15,000 lb per hr
Final air temperature desired	100 F

Heat to be removed

15,000 x .24 x 50 = 180,000 Btu/hr

As one ton of refrigeration equals 12,000 Btu per hour, total cooling load to remove the 50 F heat rise over the ambient would be 180,000 ÷ 12,000 = 15 tons of refrigeration. From this it is quite apparent that the quantity of heat to be removed is quite large and will require approximately 15 hp to drive a refrigeration compressor. This means that 1½ per cent of the engine power is required for cooling.

A rather simple device known as turbo-cooling is an effective means of cooling air. The combustion air is compressed to about double that required by the engine, recompressed by a centrifugal compressor driven by an expander turbine and cooled between stages. This device is relatively small and simple, but requires approximately 4 per cent of engine rating. The required energy may also be derived from the waste heat of the engine cycle.

Refrigeration produced directly from the waste heat in the exhaust by the Servel system of refrigeration is an effective means of cooling combustion air. This unit obviously does not use any of the shaft horsepower, but does throw some additional requirements in the cooling circuits for the refrigeration system.

Water cooling, by making use of the latent heat of vaporization makes a very simple and inexpensive means of not only cooling the air but raising the relative humidity to give what we call "conditioned combustion air." The evaporation of 22 gal of water per hour is equal to 15 tons of refrigeration. No additional cooling system is required to cool the cooling medium.

There are several combinations of using water as a cooling medium. We will discuss them in some detail beginning with the simplest and proceeding to the system giving the minimum temperature obtainable from evaporation of water.

Heretofore, it has generally been considered that evaporative type cooling equipment could be used successfully only in localities where the climate is semi-arid. An analysis of wet bulb temperatures on the Gulf Coast shows that wet bulb temperatures have not exceeded 84 F. This means that an evaporative cooler can cool air to 90 F any place in the United States. Standard rating temperatures of the Diesel Engine Manufacturers Association are based on 90 F.

Assuming initial conditions of 115 F and 100 F ambient temperatures with wet bulb temperatures of 65 F and 84 F respectively the conditioning system will accomplish as follows on a 4-cycle atmospheric engine:

TABLE 1.

	Case 1		Case 2	
Initial conditions:	115 F	DB	100 F	DB[1]
	65 F	WB	84 F	WB[2]
	2%	RH	50%	RH[3]
Cooling to within 5 deg of wet bulb gives combustion air to engines at	70 F	DB	89 F	DB
	75%	RH	70%	RH

[1] Dry bulb temperature F.
[2] Wet bulb temperature F.
[3] Relative humidity per cent.

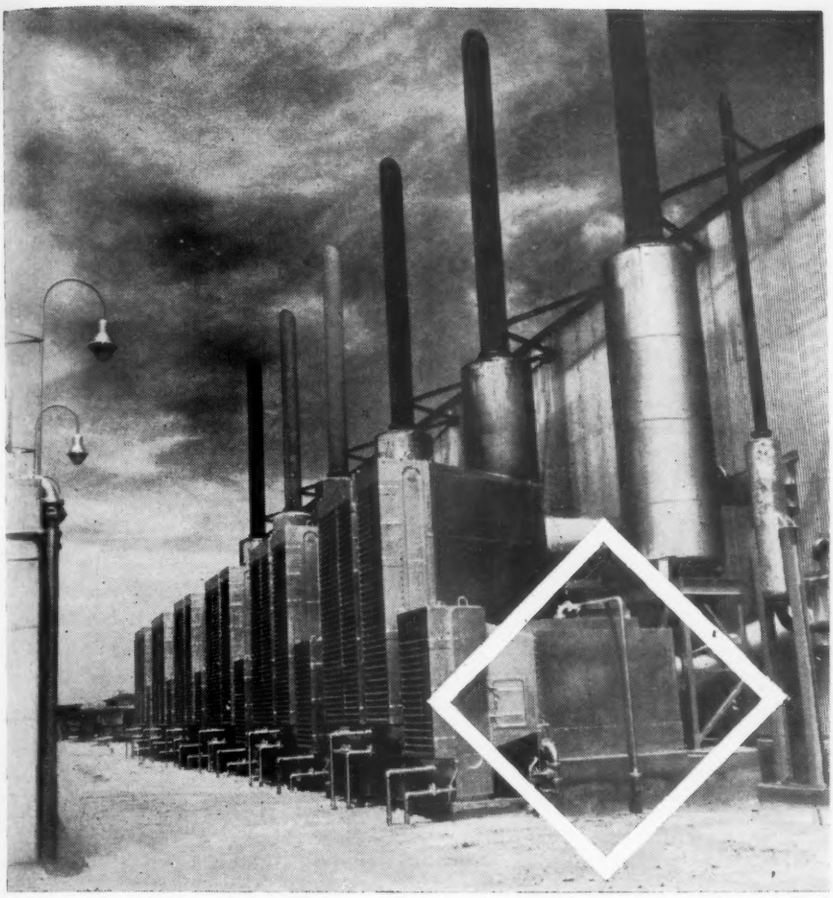


FIG. 3. INSTALLATION of an evaporative and humidifying precooler.

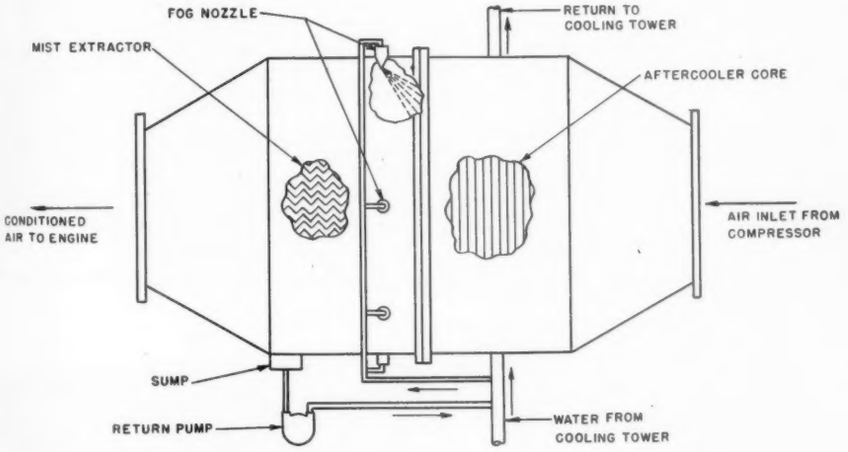


FIG. 4. COMBINED evaporative and shell air-tube aftercooler.

It might be said that the example cited in Case 1 is what can be accomplished under semi-arid conditions, while that cited in Case 2 is typical of what can be accomplished on the Gulf Coast.

The system used is shown in Fig. 1. It is simply an evaporative cooler and humidifying unit which is piped into the air inlet system to the engine. The unit is equipped with a small water pump which sprays water into the evaporative cooler through spray nozzles. Consumption of water under average conditions is .15 lb per horsepower hour and enables a drop in air temperature to within 5 F of the wet bulb. This system may be used on a 2-cycle engine, but is rather ineffective, due to the heating effect of compression.

A very effective, simple, and complete combustion air conditioning system is shown in Fig. 2. It is an evaporative cooler and humidifying unit that is interposed in the air inlet piping to the scavenging blower. The unit is equipped with a small water pump which sprays water into the evaporative cooler through fog nozzles at the rate of 50-100 gal per minute. Total consumption of water under average conditions is approximately .3 lb per horsepower hour. The evaporative cooler is capable of reducing the incoming air temperature to within 7 F of the prevailing wet bulb temperature. The aftercooler on the blower discharge is sized to lower the air temperature to within 15 F of the cooling medium temperature, which is a variable dependent upon prevailing conditions. This system is covered by the patent number 2600736 held by the Cooper-Bessemer Corporation. An engine operating under semi-arid summer conditions of 115 F DB and 65 F WB at 3000 ft altitude would normally have the air supplied to the engine at 153 F DB and a relative humidity of approximately 1 per cent. With conditioning equipment the following results can be attained:

TABLE 2.

Initial conditions	115 F	DB
	65 F	WB
After evaporative cooler	72 F	DB
	70%	RH
After compressor	107 F	DB
	29%	RH
After aftercooler combustion air supplied to engine	87 F	DB
	40%	RH

Compressor engines in operation and current production did not have sufficient room to use the system shown in Fig. 2. The system finally used was to place the evaporative cooler and humidifier between the scavenging compressor and the engine.

Fig. 3 is a photograph of a multiple installation showing the evaporation cooler in the combustion air system between the engine and the self cleaning curtain type air cleaner. This identical unit may be used to serve as the humidifying unit in Figures 1, 2 and 5.

An analysis using conditions as in Table 1 results in the following values.

TABLE 3.

Initial conditions	115 F	DB
	65 F	WB
Compressed to	4.5 in. Hg	
After evaporative chamber and to the engine	83 F	
Relative humidity to engine	75%	

Actual field results from an engine with and without combustion air conditioning gave the following results.

TABLE 4.

Ambient 103 F Wet bulb 71		
Condition of operation	Without cond.	With cond.
Air temperature to cylinder	153 F	102 F
F exh. temp. average of included exh.	540	540
Relative humidity	½% approx.	75%
Remarks	Rough combustion with light intermittent detonation	Smooth combustion all cylinders

Further gains can be made by merely adapting the same basic system in a little different manner, i.e., bring the air through the compressor and through a combined aftercooler evaporative cooler and supply to the air inlet manifold. An example of this system is shown in Fig. 4. The advantage of this system

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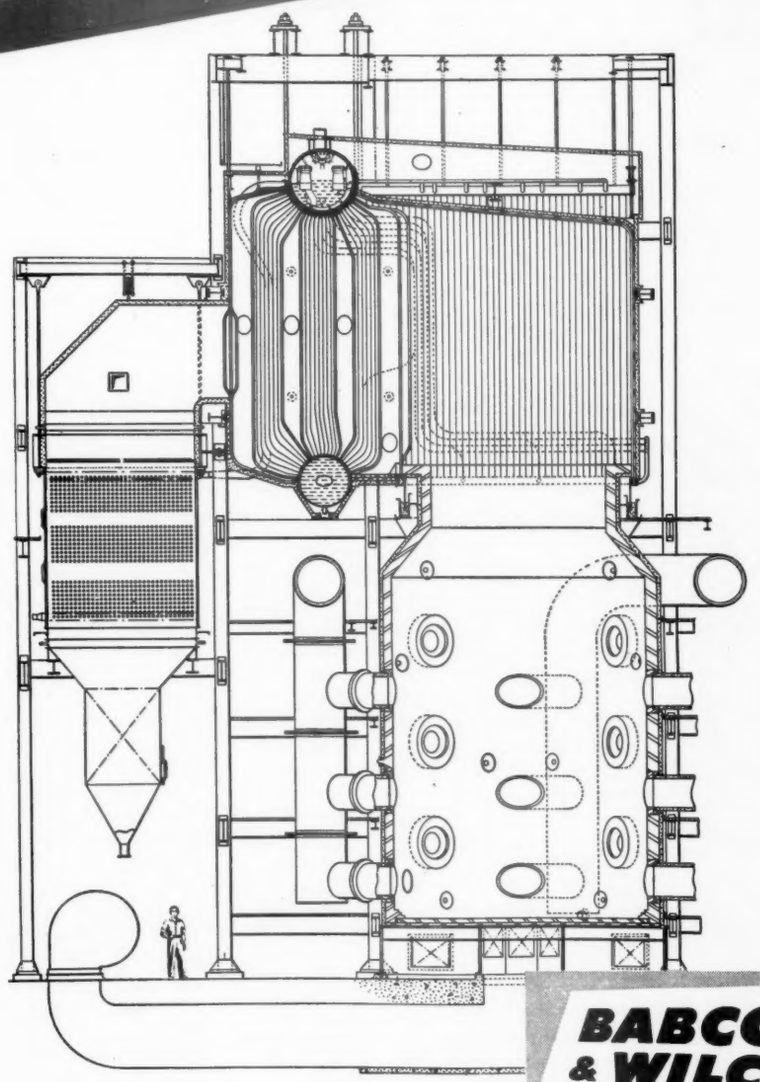
You are looking at the picture of a well-planned and well-constructed defense against the ever-present problem of refineries' rising production cost. Today's catalytic cracking units are efficient as far as the processing of petroleum is concerned, but Sinclair engineers were bothered by the fact that large amounts of potential heat were being lost in the form of combustible carbon monoxide from catalytic regenerators. By proper engineering, with the burning of supplementary fuel, the CO gas can be burned and used to generate steam, thereby reducing fuel costs.

After proving the basic soundness of the idea in a pilot plant, Sinclair, with C. F. Braun and Company as the prime contractor for the Fluid Catalytic Cracking Unit, chose Babcock & Wilcox to collaborate with Sinclair engineers on the design, with B&W as manufacturer of the CO boiler. The "saving" part of this unit is the B&W CO Boiler, that burns as fuel the combustible CO and entrained hydrocarbons that are usually expelled

R ON STREAM



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from the regenerator as a waste gas. The new B&W CO Boiler does a double job—generates steam to run the entire fluid unit and its auxiliaries while having an appreciable excess capacity available for general refinery use.

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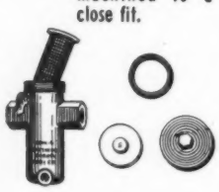
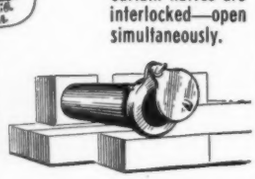


Wide-View Peephole, safety, curtain type. Cobalt glass removed to show bearing surface for curtain. Curtain halves are interlocked—open simultaneously.

Ignition Port with Refractory Tile No. M896 . . . for use with standard 3" pipe. Also serves as a peephole.



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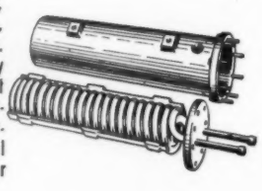

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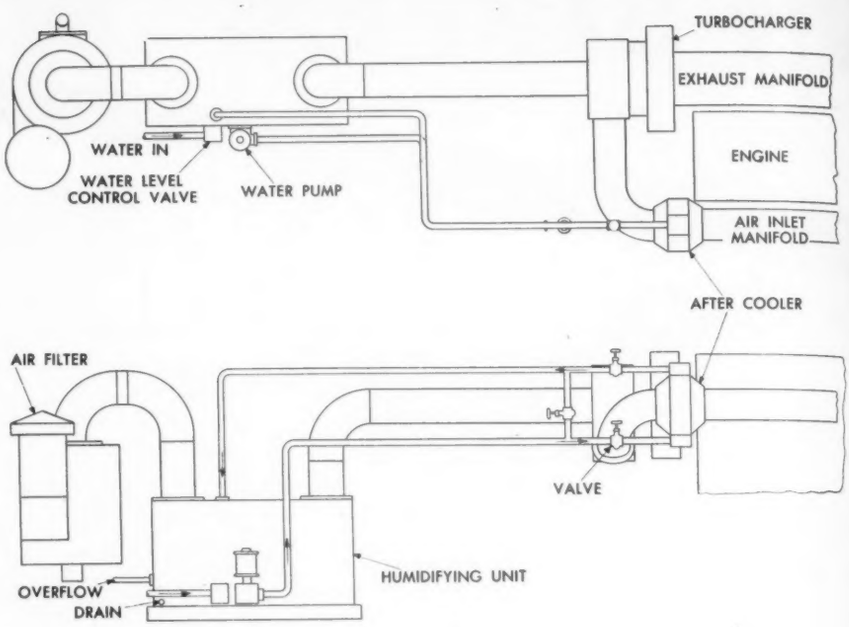

FIG. 5. COOLER system for a 4-cycle turbocharged engine.

is that it utilizes the aftercooler more efficiently than is possible with the one shown in Fig. 2. The humidifying efficiency of the evaporative cooler is also improved in that it is used on the pressure side of the compressor rather than on the inlet. If we assume the same initial conditions as stated earlier, combustion air can be supplied the engine as follows:

TABLE 5.

Initial conditions	115 F	DB
	65 F	WB
Air from compressor	153 F	DB
	77 F	WB
Air from aftercooler	95 F	DB
	59 F	WB
Air from evaporative cooler supplied engine	66 F	DB
	66%	RH

It is quite apparent that the air conditioner as shown in Fig. 4 does even more than merely lower the temperature of the combustion air to a value less than that possible, shown in Table 1 by the unit shown in Fig. 2. The combustion air is supplied the engine 21 F lower than in Table 4 while the relative humidity is raised from 40 per cent to 66 per cent. This gain is particularly significant in that it is to our advantage to supply, particularly gas engines, with air that is as near saturation as possible. The effect of humidity is primarily suppression of detonation, more orderly flame propagation, and a lower mean temperature within the combustion chamber. High humidity also enables an advance in ignition timing, thus lowering cylinder and exhaust temperatures even more. The same is true of diesel engines, but is not considered as important as on high compression spark ignited gas engines.

The same basic principle is also in current use on 4-cycle supercharged gas, gas diesel, and diesel engines. Fig. 5 indicates a typical system on an engine equipped with an exhaust driven turbocharger. In this system the evaporative cooler on the air inlet to the turbocharger is capable of lowering the air temperature to within 7 F of the prevailing wet bulb, while the aftercooler on the turbocharger discharge will lower the air temperature to within 25 F of the cooling medium temperature. The wider approach on the aftercooler is a compromise and is dictated by space limitations.

A typical 4-cycle supercharged engine operating under the same conditions presented earlier of 115 F DB and 65 F WB at 3000 ft altitude with a charging pressure of 15 in. mercury would supply air to the engine at 225 F without conditioning equipment. With conditioning equipment the following results are obtained:

TABLE 6.

Initial conditions	115 F	DB
	65 F	WB
After evaporative cooler	72 F	DB
	70%	RH
After turbocharger	182 F	DB
	5%	RH
After aftercooler		
Combustion air supplied the engine (80 F water)	105 F	DB
	37%	RH

If the same supercharged engine is equipped with the more efficient combined aftercooler-evaporative cooler combination shown in Fig. 4, conditions could be attained as follows:

TABLE 7.

Initial conditions	115 F	DB
	65 F	WB
After turbocharger	225 F	DB
	5%	RH
Air from aftercooler	105 F	DB
	6%	RH
Air from evaporative cooler supplied engine	71 F	DB
	66%	RH

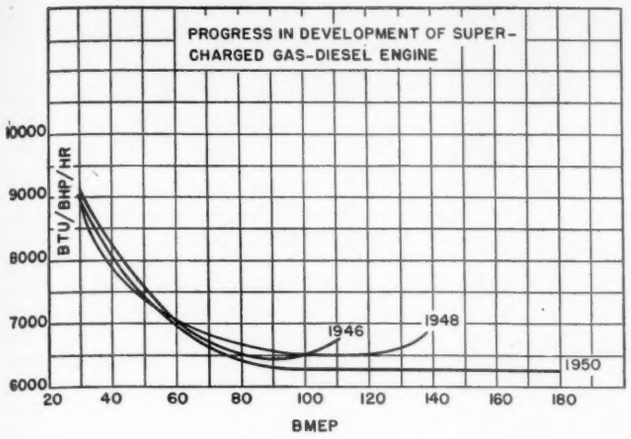

FIG. 6. COMBUSTION characteristics between 1946 and 1950, judged by borderline detonation.

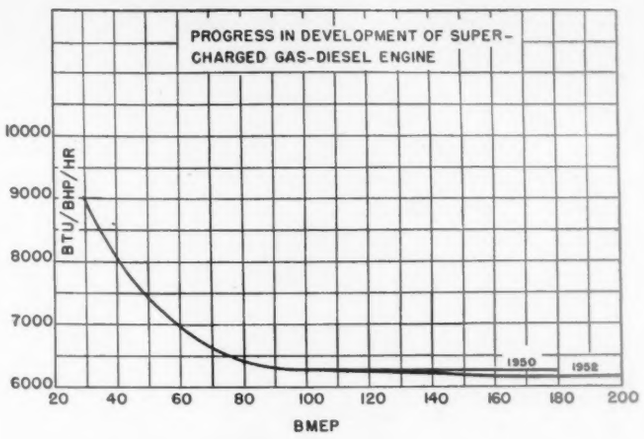

FIG. 7. IMPROVED COMBUSTION characteristics for the application of combustion air conditioning only.

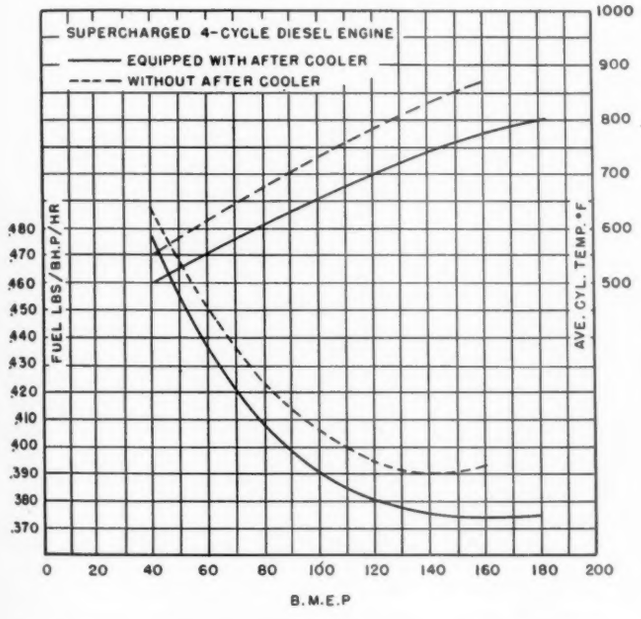

FIG. 8. FUEL CONSUMPTION and exhaust temperatures vs. load, with and without combustion air conditioning.

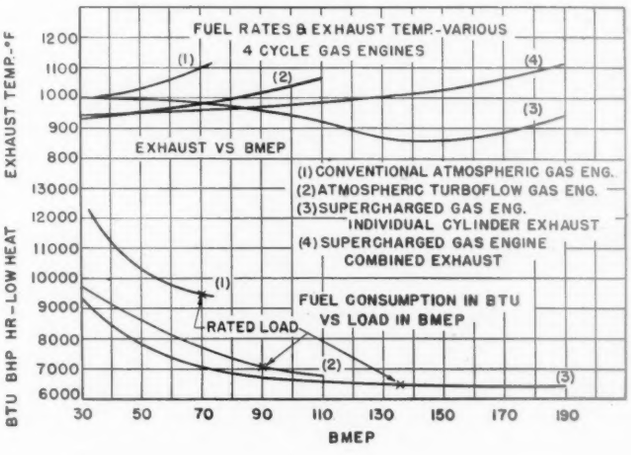

FIG. 9. DIRECT comparison of three types of gas engine operation.

Space limitations quite naturally govern the amount of equipment that can be used on engines of this type. Improvements in evaporative cooler design, however, are now being effected that will enable the conditioning of combustion air to the values indicated in Table 7.

Gas turbines that are creating considerable interest throughout the industry are benefited by combustion air conditioning. The gas turbine manufacturers realize this and have taken advantage of lower air temperature by establishing 80 F ambient as a basis of rating rather than 90 F established by engine manufacturers. If the ambient temperature to a simple cycle, single rotor gas turbine is 100 F the load pulling ability is reduced by 10 per cent and the thermal efficiency is reduced from approximately 23 per cent to 18½ per cent. If combustion air conditioning were used, no derating for high ambient temperature would be required in this section of the country.

Specific gains and engine plant adaptations aided by the use of combustion air conditioning. The amount of fuel that can be burned in the cylinder of heavy duty engines is no longer the limiting factor for continuous ratings. We have long been familiar with this in the airplane engine with its two ratings which are designated as take off and cruising ratings. The cruising rating is the load at which the heat dissipation is sufficient to keep internal surfaces from exceeding the safe operating temperatures. Cool combustion air on 2-cycle engines and 4-cycle supercharged engines is flushed through the cylinder and some heat removed off the internal surfaces. Since learning how to burn gas under higher compression in 1946, we have been able to increase the pulling ability of our engines by approximately 5 per cent per year. Much of this has resulted from combustion air conditioning.

Fig. 6 shows the progress made between 1946 and 1950 in increased output judged by borderline detonation.

Fig. 7 shows the increased pulling ability, by improved combustion air conditioning alone.

Fig. 8 shows the relation of fuel consumption and exhaust temperature vs. load on an engine with and without combustion air conditioning. At the full load rating the fuel consumption has been reduced 4 per cent. The heat load on the internal parts, judging from exhaust temperature, is the same at 180 BMEP when using combustion air conditioning as 128 BMEP without conditioning.

Fig. 9 is to show the direct comparison of the exhaust temperature and fuel consumption of 3 styles of operation on the same engine.

Curve 1 is for an atmospheric engine.

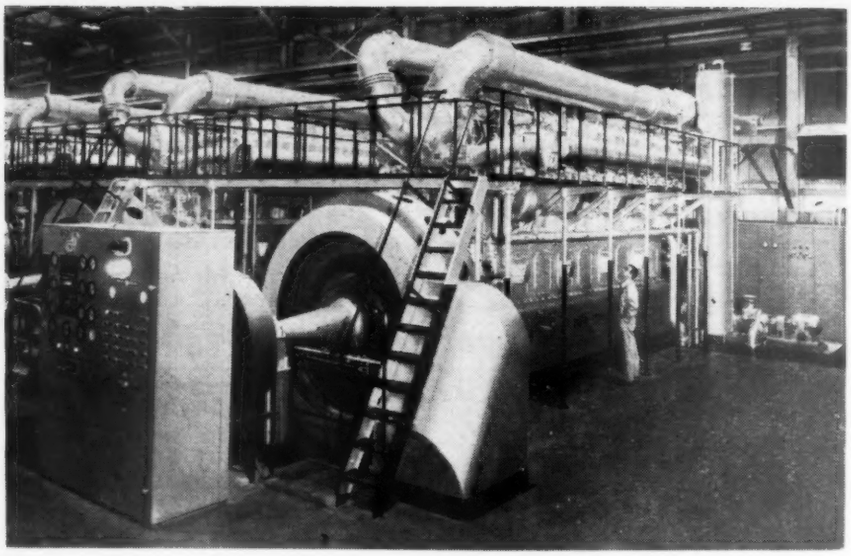

FIG. 10. A 270,000 hp gas engine power unit, where supercharging and air cooling has cut size of plant approximately in half.

TABLE 8. Postscript of study giving a summary of cost of various methods of combustion air conditioning and plant value saved by using various types of equipment with various prime movers.

Power unit designation	Nominal rating horsepower	Ambient temp. F	Wet bulb temp. F	Method of air conditioning	*Water evaporated gal/hp/hr	Min air temp. with given conditions F	Derating required without conditioning hp	Cost of conditioning equipment per hp at nominal rating	Net savings using all conditioning installed at cost of $200 per horsepower	Remarks
High efficiency atmospheric gas engine	2500	105	65	Water evaporation	.0035	90	112	$ .60	$ 20,900	
Super-charged 4-cycle gas engine	3700	105	65	Water evaporation	.0230	100	710	.81	139,000	
Super-charged 4-cycle gas engine	3700	105	65	Water evaporation	.0280	80	710	1.95	134,800	Special for low grade fuel
Super-charged 4-cycle gas engine	3700	105	65	Water radiator and refrigeration	None	100	710	1.45	130,420	
Super-charged 4-cycle gas	3700	105	65	Water radiator and refrigeration	None	60	710	3.30	124,000	Special for low grade fuel
Gas turbine	5000	105	65	Water evaporation	.047	80	625	1.00	120,000	
Gas turbine	5000	105	65	Separate engine driven refrigeration	None	80	500	8.60	82,000	
Gas turbine	5000	100	65	Separate engine driven refrigeration	None	80	625	7.85	62,800	
Gas turbine	5000	100	65	Separate engine driven refrigeration	None	60	+500	11.45	145,000	Decreased temp. permits increased rating

* Double of this amount is required if no other use is available to prevent concentration of solids in water.
Note: At present ratings in use on 2-cycle engines, combustion air conditioning is not economically justifiable except where fuel gas has heavier hydrocarbons along with high ambient temperatures and low relative humidity.

Curve 2 is for an atmospheric high compression gas engine.

Curves 3 and 4 for supercharged gas engines. Note the individual exhaust temperatures are 240 F lower than for atmospheric gas engines, which have established their reliability and long-life.

Fig. 10 is the photograph of the power section of an aluminum plant where approximately 270,000 hp of gas engines are in operation. Supercharging and cooling has cut the size of this engine plant in approximately half.

In summarizing the benefits of combustion air conditioning, we can say that it:

1. Permits increased engine ratings, thus making direct savings in foundation and building costs.
2. Lowers specific consumption.
3. Improves combustion characteristics by more orderly flame propagation thus reducing combustion noises.
4. Lowers the heat load on all cylinder parts. The heat load on the cylinder assembly is the present limiting factor for continuous rating.
5. Eliminates deration for high ambient temperatures.

We believe that the growth of combustion air conditioning will be rapid since it has won recognition for its true worth. * * *

What Horsepower to Overcome Air Resistance?

The above question is frequently asked. The reply can be made very complex because exceedingly exhaustive studies of air resistance have been made in connection with the perfecting of airplanes. However the writer will not go that far into the subject. He offers herewith a simple chart of his construction based on a formula credited to Brooks.

Across the chart a dotted line is drawn which shows how the horse power is determined for a car, truck, or other object running at a speed of 60 miles per hour. Column A, whose projected area is 30 sq ft, Column C. The answer is found at the intersection of the dotted line with Column B, and is about 85 hp. Thus, all that is necessary is to lay a straightedge across the chart and the middle column immediately gives the horse power required to overcome air resistance at any speed up to 150 miles per hour, and for a range of projected areas from 10 to 100 sq ft.

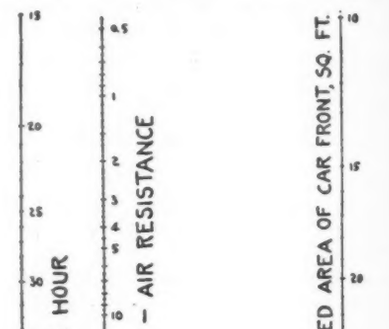

Chart to determine horsepower needed to overcome air resistance.

To find the projected area of a moving object, multiply the average width of the object by its average height. Thus if the average width is 6 ft, and the average height is 5 ft, the projected area is 30 sq ft. Where the object runs against or with the wind the velocity of the wind must be either added or subtracted, as the case may be.—WFS.

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Sampling from continuously-flowing feedwater streams gives most consistent results with one ppm hardness

E. W. ELLIS and H. E. CARLSON

IMPORTANCE of effective feedwater conditioning for steam generators at a refinery can scarcely be overemphasized. Notwithstanding the fact that the steam power plant is the heart and pulse of any refinery, it is frequently the case that relatively little attention is given to it until, through neglect, expensive repairs become necessary, or one or more oil processing units are threatened with a shutdown because of an insufficient steam supply. It can be stated with little chance of serious contradiction that more trouble in boiler operation can be caused by inadequate or no water treatment than by any other factor. Scale on heating surfaces, even thin layers, reduces appreciably heat transfer between the heat source and the water, a condition which results in significant fuel waste and in possible overheating of the metal adjacent to the scale. Such overheating often is sufficient to cause tubes or tube sheets to warp to such an extent that leaks develop where tubes are rolled into the header. Of course, no one attempts to operate a high pressure boiler plant at, say, 450 psi or higher, without proper feedwater treatment; but the authors have observed many boiler plants, including some refinery steam plants, operating at 100 to 250 lb pressure where feedwater treatment was carried out in a haphazard manner with inadequate or no systematic testing and control program in effect. Such practice resulted in scale accumulation or corrosion.

A few years ago, a hot lime-soda and hot phosphate treating system was installed at the Cities Service Oil Company, East Chicago, Indiana refinery, which has been eminently successful in producing de-aerated feedwater of very low hardness. The hardness consistently runs less than one part per million calcium carbonate. The original installation included only the lime-soda softener, by means of which hardness was reduced to 5 to 6 parts per million by considerable over-treating. At that time, disodium phosphate was periodically "slugged" into each boiler feed line about a foot from the boiler steam drum. Considerable difficulty was encountered with feedline deposits even in the short length of line between the point of phosphate injection and the drum. Since adding the hot phosphate treater, no feedline deposits have occurred, and feedwater of very low hardness has been produced continuously with practically no interruption other than an occasional failure of a timing mechanism. Boilers are removed from service annually for inspection and are always found to be completely free from scale, corrosion, and pitting.

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The Authors

E. W. Ellis

H. E. Carlson

Edgar W. Ellis began his career in the petroleum refining industry in 1924 as a laboratory assistant for Panhandle Refining Company, Wichita Falls, Texas. After a year's service he resigned to attend the University of Texas from which institution he received a BS degree in chemical engineering in 1929. He was awarded an MS degree a year later, and remained at Texas as an instructor in chemical engineering until 1933 when he returned to Panhandle as chief chemist at the refinery. Ellis remained at Panhandle until 1941 and during World War II, and for some time thereafter, he was a chemical engineer in government service.

For the past six years Ellis has been resident chemist in charge of the East Chicago refinery laboratory of Cities Service Oil Company (Delaware).

Harold E. Carlson attended Iowa State College, Ames, Iowa, and received a BS degree in chemical engineering in 1940.

He worked five years as fuel engineer and two years open hearth fuel foreman for United States Steel, Gary Works, Gary, Indiana.

In 1947 he began working for Cities Service East Chicago refinery. For the last five years has been in charge of boiler house and water treating.

Water Treating System

Only a brief description of the treating system itself will be presented since lime-soda and phosphate treating methods have been well established for many years and modern equipment for the application of these processes is available from a number of reputable firms. Most of the subject matter of this paper will consist of control methods, which in the opinion of the authors, have been largely responsible for the success of the treating processes.

At East Chicago, about one million gallons per day of raw Lake Michigan water is treated successively by lime and soda ash plus sodium aluminate in one sedimentation tank, and anhydrous disodium phosphate in another tank in series. A photographic view of these mixing tanks is shown in Fig. 1, the somewhat larger unit in the background being the lime-soda softener. As the feedwater and chemicals enter the lime-soda softener, they are sprayed into an atmosphere of live steam which heats the mixture to about 218 F for liberating dissolved oxygen and carbon dioxide. The de-aeration is sufficiently effective that no oxygen scavengers, such as sodium sulfite, have been found necessary. A blanket of steam is also maintained above the water in the phosphate softener. Liberated gases from the water are swept out of the system through a vent condenser by a moderately strong flow of steam. The amount of escaping steam is controlled by the amount of raw, cold water allowed to go through the vent condenser tubes.

Hardness of the water is reduced from about 140 to approximately 10 ppm calcium carbonate in the lime-soda softener with the aid of sodium aluminate as a coagulant for the sludge. The sludge consists of fluffy magnesium hydroxide and calcium carbonate. The water, which has settled fairly clear by the time it leaves the softener, enters the top of the phosphate softener with disodium phosphate. In both softeners, the water enters the top of the vessel with chemicals, flows downward through an inner cylinder, which extends to the top of the

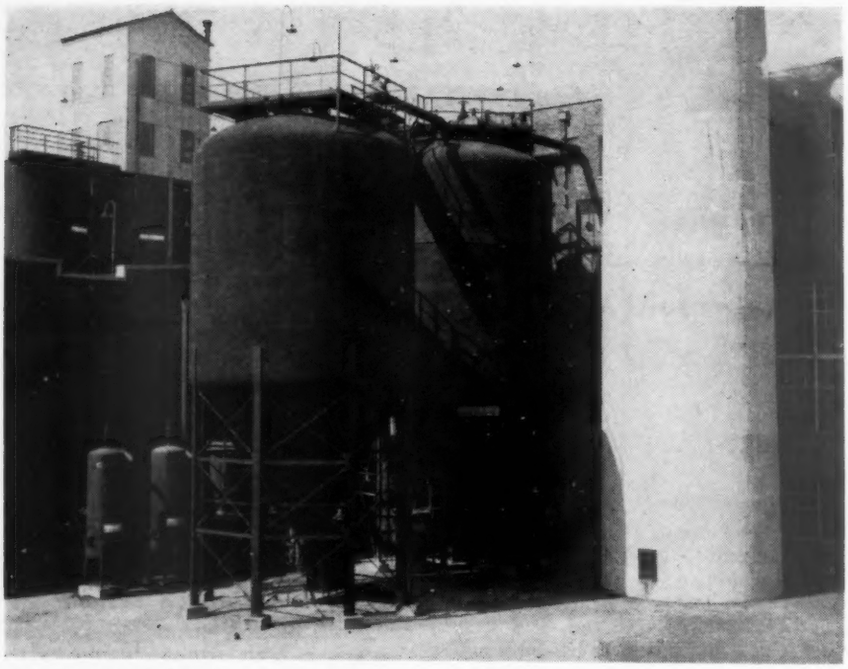


FIG. 1. PHOSPHATE and lime-soda water softeners at Cities Service's East Chicago refinery.

cone bottom of the softener, and then flows upward in the annular space between the inner cylinder and the outer shell. The phosphate softener effluent flows to anthrafilt filters from which perfectly clear, soft, de-aerated water is picked up by boiler feed pumps for delivery to seven boilers in the main steam plant and also to five wasteheat steam generators at the fluid catalytic cracking and delayed coking units. Chemicals are fed to the softeners in liquid suspension or solution, the flows of which are proportional to the volume of raw feedwater entering the system. A view of part of the solution tanks and chemical feed system is shown in Fig. 2. An orifice meter which measures the feedwater actuates timing mechanisms which control the flow of chemicals to each softener. Hydrated lime is kept in suspension by means of a mechanical stirrer, and sodium aluminate is added to the lime slurry at the rate of 10 per cent of the weight of hydrated lime. Soda ash, disodium phosphate, and organic sludge conditioner are made up by weight in separate solutions with steam condensate. The organic sludge conditioner is added to the suction of the boiler feed pumps. Hydrated lime and soda ash are purchased in bulk car lots and unloaded by suction into elevated storage tanks from which they flow by gravity onto scales below. Scale hoppers are constructed so that chemicals can be transferred to the proper solution or suspension tank below by means of a screw conveyor. All other chemicals are purchased in bags and made up in solution form as required.

An important adjunct to the lime-soda treatment is the re-circulation of a portion of the sludge from the cone bottom of the vessel, back to the top where it mixes with incoming chemicals and raw lake water. The re-circulated sludge materially improves the effectiveness of lime-soda-sodium aluminate treatment.

Control Methods

Trained control chemists are on duty 24 hours a day to run analyses on softener effluents and boiler water. In order that these tests be of maximum value, it is of paramount importance that all samples for test be truly representative of the main body of water from which each sample is taken. In order to insure representative samples, equipment must be provided that will make sample taking convenient and practically independent of any variation in sampling technique on the part of those who take the samples. This is accomplished at Cities Service by having constantly flowing streams from each softener effluent and from each boiler through cooling coils to a convenient location for taking the samples. The softener effluent sampling streams are piped to a point immediately above the boiler house laboratory sink and flow into the sink continuously. Sampling streams for boiler water are branched off the continuous blowdown lines and each flows continuously through an individual cooling coil surrounded by flowing cooling water. The boiler water sampling arrangement is shown in Fig. 3. All samples are thus obtained by merely holding a container under continuous flowing, cool streams with no valves to open and no lines to flush out. Such samples are much to be preferred over "gage glass" samples or samples obtainable only after flushing a lengthy sampling line, where often there is no cooling coil attached to the sample lines so that flashing occurs, and the person taking the sample is subject to being burned with the hot liquid.

Regular chemical analyses are the basis for controlling the amount of

FIG. 2. CHEMICAL solution tanks, pumps, and feeding system.

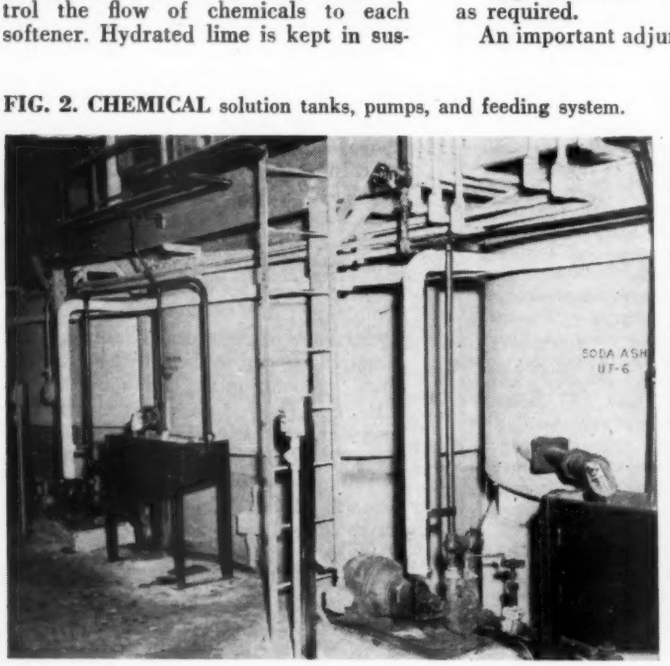
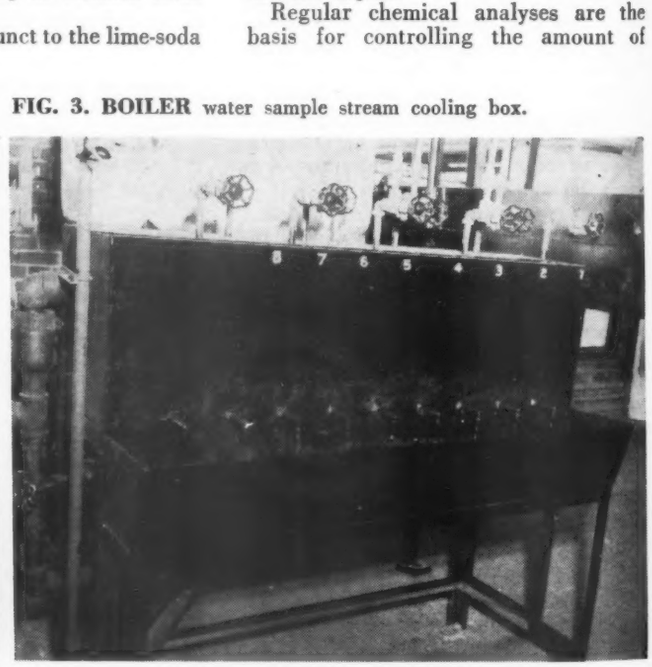


FIG. 3. BOILER water sample stream cooling box.



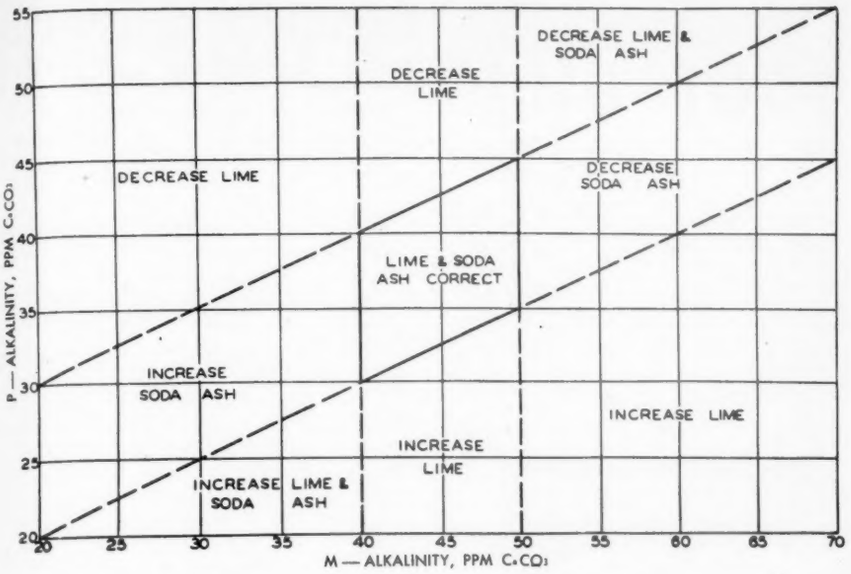


FIG. 4. SUITABLE quantities of lime and soda can be controlled most conveniently from this chart.

chemicals used in treating the feedwater. Table 1 shows control limits and frequency of test for all tests.

For the lime-soda softener, excesses of lime and soda can be calculated from the P and M burette readings, but proper quantities of these chemicals may be more conveniently controlled by means of the chart shown in Fig. 4. If the P and M alkalinities, calculated as parts per million calcium carbonate intersect within the parallelogram near the center of the chart, the lime and soda excesses will be correct to provide the proper alkalinity in the phosphate softener for efficient removal of residual hardness in the lime-soda effluent. In the extreme upper portions of the parallelogram, on the chart, little or no excess soda ash is indicated. However, the excess lime is sufficient to provide proper alkalinity for practically complete hardness removal in the phosphate softener if 1 to 5 ppm excess phosphate is maintained in the phosphate softener effluent. When there is little or no excess soda ash in the lime-soda effluent, more than normal disodium phosphate is required to provide 1 to 5 ppm excess in the next stage of treatment, but in such cases the final hardness of the feedwater is just as low as if 8 to 10 ppm excess soda ash had been provided.

It has been observed that residual hardness in the lime-soda effluent may be reduced to values much lower than 8 to 10 parts per million by overtreating to a greater extent with lime and soda, but the phosphate effluent in such cases, which is the boiler feedwater, increases to 3 or 4 parts per million hardness. These observations show that there is an upper limit to the alkalinity for most efficient phosphate softening. This upper limit has not been determined, but excesses of lime and soda ash as represented by the parallelogram on the chart, are known to represent optimum conditions for precipitating calcium hardness as very insoluble tricalcium phosphate. On the chart it will be noted that any point on the upper diagonal line represents 40 ppm calcium carbonate as excess lime and the lower diagonal 20 ppm. When the P and M alkalinities intersect outside the parallelogram, the captions indicate roughly the adjustment in chemical treatment required to correct the condition. Obviously, only directional changes are indicated and final correct conditions can be obtained only by trial.

It will be noted from the Table that tests on each softener are run at two-hour intervals throughout the twenty-four hour day. This schedule provides close control on softening operations so that the boiler water need be checked only for total dissolved solids (TDS), for blowdown control.

Hydroxide alkalinity and phosphate tests on the boiler water are, in reality, not necessary except as an additional check to make sure that conditions inside the boilers are satisfactory. Tests for dissolved oxygen in the feedwater have been made at infrequent intervals and no oxygen found to be present. Deaeration is complete as long as a strong flow of steam issues from the vent condensers on top of the lime-soda softener.

TABLE 1. Chemical treatment control.

Source of sample	Test	Test intervals hours	Control limits
Lime-soda effluent	P&M*	2	Excess lime, 20–40 ppm $CaCO_3$
Lime-soda effluent	P&M	2	Excess soda, 6–14ppm $CaCO_3$
Lime-soda effluent	Hardness	2	Not controlled
Lime-soda sludge	Settling	2	Approximately 60% minimum
Phosphate effluent	PO_4 ion	2	1 to 5 ppm PO_4
Phosphate effluent	Hardness	2	Under 1 ppm $CaCO_3$
Main boilers	OH ion	8	Not controlled
Main boilers	PO_4 ion	8	Not controlled
Main boilers	TDS	8	Approximately 2500 ppm
Oil unit boilers	TDS	8	Approximately 2500 ppm
Organic sludge cond.	Visual	8	Medium dark color
Sodium aluminate	.....	..	10% of weight of dry lime

* Phenolphthalein — Methyl purple titration equivalent to the conventional phenolphthalein — methyl orange titration

Analytical Methods

The phenolphthalein-methyl purple titration for alkalinity is a time-honored test. Most chemists agree that methyl purple exhibits a sharper color change at the end point that mythyl orange, and is used for that reason. The end point occurs at a pH value of about 4.8.

The test for total hardness is a very accurate, direct titration method described by Betz and Noll,[1] except that the hardness indicator (Eriochrome Black T) is made up in c.p. diethanolamine according to Diskant,[3] who found that this material produces a much more stable indicator solution than other solvents. This method for hardness determination is very easily run and, with proper care, is accurate to 0.1 ppm calcium carbonate hardness according to later investigations by Betz and Noll.[2] Such accuracy and convenience cannot be approached by any other known method and is far superior to conventional soap hardness tests, or even the more accurate "soda reagent" hardness test. An improved Brown microburette of 2 ml capacity has been found convenient and essential for accurately determining hardness at the very low values shown by the phosphate softener effluent.

A settling test on the re-circulated sludge from the lime-soda softener is an empirical test found to be satisfactory. It consists merely of taking a 100 ml sample from the re-circulating pump in a graduated cylinder and reading the top of the sludge layer after five minutes settling time.

Excess phosphate ion is determined colorimetrically by means of a Taylor slide comparator. Reagents added to the water sample containing soluble phosphate develop a blue color, the intensity of which is proportional to the concentration of phosphate ion present. The Taylor comparator slide contains permanent blue color standards corresponding to definite concentrations of phosphate. The comparator is relatively inexpensive and may be purchased at laboratory supply houses. An important time saver in running this test is the use of a special mixing tube designed by the Tru-Test Laboratories of Philadelphia, which fits into the Taylor comparator. The water sample and phosphate reagents can be mixed in this tube and the tube placed directly into the comparator, thus eliminating the necessity of transferring part of the blue-colored solution from a regular Taylor mixing tube to a small vial which will fit the holes of the comparator. The colorimetric determination of phosphate ion in the boiler water which is colored by the organic sludge conditioner requires decoloration before testing. This is most conveniently accomplished by means of Norit A, a decolorizing carbon, according to procedure presented by Goldman and Love.[4]

Hydroxide alkalinity in the softened feedwater is determined satisfactorily by the P and M titration as described above,

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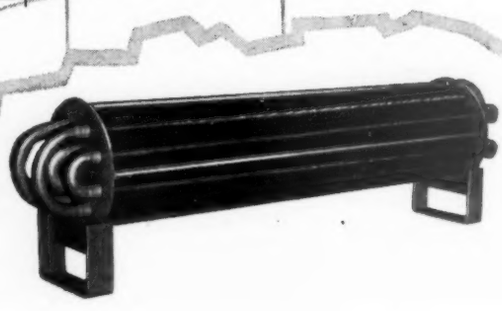

but in boiler water, which is much more concentrated, the classical Winkler method of precipitating the everpresent carbonate ion with barium chloride and titrating the resulting solution with standard acid to the phenolphthalein end point is considered better.

Total dissolved solids (TDS) is determined on boiler water quickly and with sufficient accuracy for blowdown control by the conductivity method developed by Maguire and Polsky,[5] who recommend the use of gallic acid powder for neutralizing the hydroxyl ion before measuring the electrical conductance. The conductance thus measured is correlated with evaporation tests, and a chart prepared from this correlation is used to convert micromhos to TDS. In the absence of evaporation data on total dissolved solids, as a rough approximation, a multiplying factor of 0.87 may be used to convert micromhos conductance to parts per million total dissolved solids.

In the preceding discussion, treatment-control methods have been discussed in some detail. The importance of obtaining representative samples has been emphasized, and it has been pointed out that the most satisfactory method of obtaining good samples is from constantly flowing streams through cooling coils. A brief discussion of chemical feed control at the Cities Service, East Chicago plant, and analytical methods considered by the authors to be the most accurate and rapid known to the water treating field, have been presented.

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2. Ibid., 749-54.
3. Diskant, Eugene M., *Anal. Chem. 24*, No. 11, 1856-7 (1952).
4. Goldman, L., and Love, R.N., *Power Plant Engineering*, 76-79 (Nov. 1946).
5. Maguire, J. J., and Polsky, J. W., *Combustion, 18*, No. 11 (May, 1947). ★ ★ ★

CORRECTION

The following corrections and additions should be made to the article, "PRESSURE DROP CALCULATION IN BUBBLE PLATE COLUMNS," by Dr. Ju Chin Chu, that appeared in the Refining & Gas Processing Edition of THE PETROLEUM ENGINEER, March, 1951, page C-9 et seq;

(1) Eq. (17), p. C-12 should read

$$h_r = 0.0097\left[\sqrt{S_G V_r}\,\frac{2A_u^2}{A_m A_c}\right]^{1.74}$$

(2) "A_c" in Fig. 2, p. C-12, third column, should be "A_a."

(3) Add to "Nomenclature," p. C-16,

A_s = Slot area defined as the total area of the completely open slot in a given bubble cap.

A_a = Annular area of the bubble cap.

PROCESS EQUIPMENT NEWS

PUBLISHED BY FABRICATED PRODUCTS DIVISION, THE M. W. KELLOGG COMPANY JUNE-JULY 1954

More Fizz for New York's Sodas

More carbon dioxide—for use this summer in carbonated beverages bottled in the New York area—is the worthy purpose behind this condenser, shown below during the tube loading operation in Kellogg's shops earlier this Spring. During the hot weather season it condenses some 30,000 pounds of carbon dioxide an hour, enough to supply the fizz in something like seven million bottles of soda pop.

On the technical side, one of the more unusual service conditions for the condenser is an extreme pressure differential of over 1300 pounds per square inch. Carbon dioxide on the shell side will be held at a pressure of 1400 psig. Water will circulate in the tubes under a pressure of 80 psig.

The unit will consist of two shells, each with 250 tubes, ¾ inch in outside diameter by 20 feet in length. The two sections are of forged, integral-channel, fixed-tube-sheet construction with admiralty tubes and steel shell cover, channel, and tube sheets.

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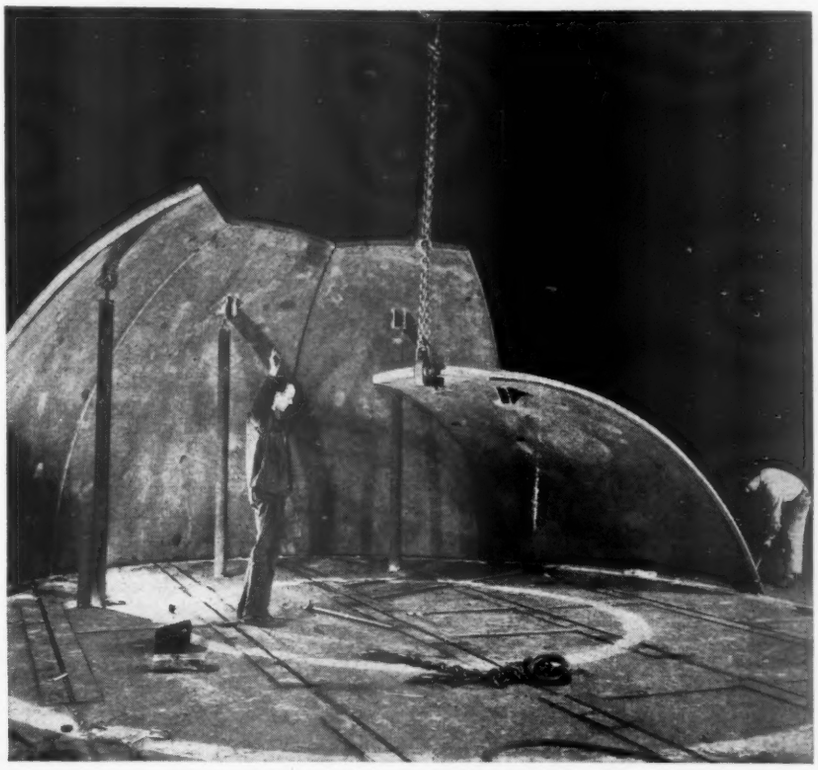

Mammoth Pressure Vessel for Oil Refinery to Be World's Heaviest

The world's heaviest process vessel, and one of the largest ever built, is now being fabricated in the Kellogg shops at Jersey City. When completed, the vessel—it comprises the reactor and regenerator of a unique Fluid Hydroforming plant—will stand well over 200 feet high and weigh approximately 650 tons.

Knockdown assembly of certain portions as well as complete fabrication of others will be accomplished in the shop before the various sections are shipped to the field for installation.

The illustration above shows the pressed head sections, cut to exact size, being joined together. The four "orange-peel" sections form half of the bottom head of the vessel. After the other half of the head is fabricated in the same manner, the two halves will be fitted up and match-marked in the shop, then shipped to the job site for final assembly.

The reactor vessel, which will be approximately 135 feet high and have an internal diameter of 23½ feet, will be topped by a smaller vessel, 12½ feet in diameter and 74 feet high, in which catalyst for the reforming process will be regenerated. Over all height of the completed unit, exclusive of the supporting pedestal, will thus exceed 200 feet.

Like the bottom head, the top head and the nine courses for the shell of the large reactor will be shipped to the job site in longitudinal halves. The smaller regenerator vessel will be fabricated in the shop, stress relieved in one of Kellogg's huge furnaces, and shipped to the job site fully assembled. Stress relieving of the welds in the reactor, in itself a job of tremendous magnitude, will be done in the field after the vessel is erected.

The reactor is being fabricated of carbon-moly steel plate, varying in thickness from 2 inches for the top head to 2¾ inches for the lower shell courses and bottom head. Chrome-moly steel plate will be used for the regenerator section.

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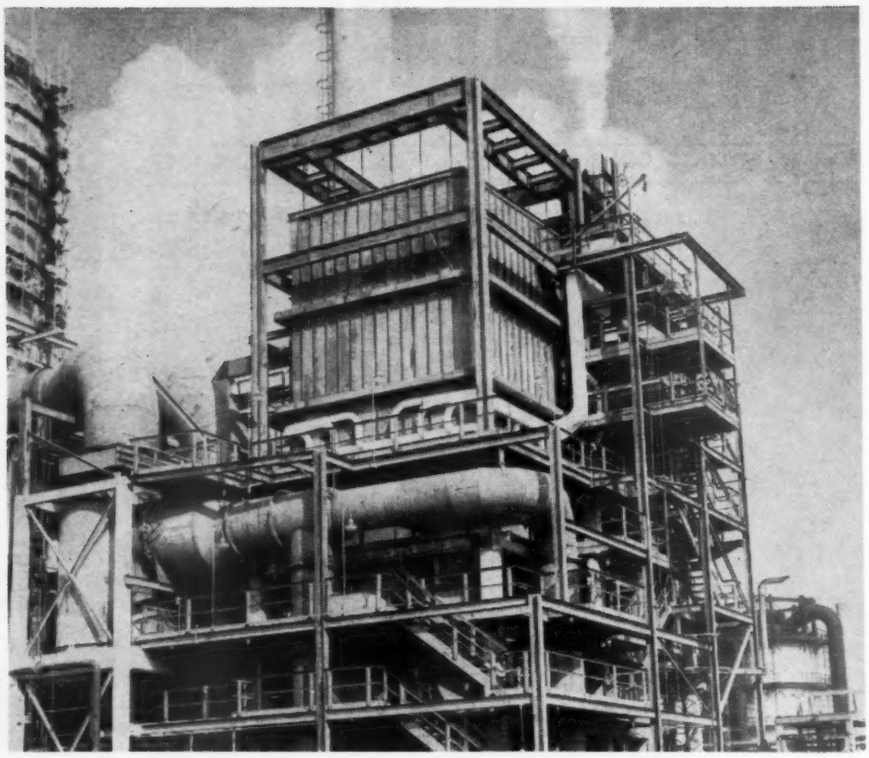


FIG. 1. Installation of large-scale CO boiler in connection with fluid cat cracker in Sinclair refinery, Houston, Texas

Cat Cracker CO Boiler and Fluidized Bed Steam Superheater

110,000,000 Btu auxiliary heat permits recovery of 220,000,000 Btu from regenerator flue gases

O. F. CAMPBELL and N. E. PENNELS

APPROXIMATELY 400,000 lb per hour of 550 psig, 750 F total temperature steam production is a unique feature of Sinclair Refining Company's new fluid catalytic cracking unit at its Houston, Texas, refinery.

More than 300,000 lb per hour of 700 psig saturated steam are produced on the oil industry's first direct fired unit to recover both the sensible heat and the heat of combustion from the high temperature regenerator exit flue gas. Heat of combustion of the regenerator exit flue gas is derived from its CO content. (Fig. 1). Saturated steam produced on the boiler is superheated to 750 F total temperature in industry's first fluidized bed respray steam superheater. The superheater respray feature produces approximately 100,000 lb per hour of additional steam and allows simultaneous control of both the regenerator bed temperature and the steam superheat.

This equipment is a further development of Sinclair's fluid catalytic cracking operations and augments its continued policy of attaining maximum fuel economy. Sinclair fluid units have all been of the non-heat balance type to insure better product distribution and more flexible control of cracking conditions. Sinclair's policy of maximum fuel economy has on previous fluid unit installations led to extensive recovery of waste heat. Unburned carbon monoxide in the regenerator exit flue gas, however, presented a further great opportunity to create and utilize additional energy. These policies of fuel economy and non-heat balance type fluid units are blended into carbon monoxide boiler to recover both the sensible heat and the heat of combustion of carbon monoxide contained in the regenerator flue gas and a respray steam superheater in the regenerator catalyst bed to superheat the steam, and in turn control regenerator bed temperature.

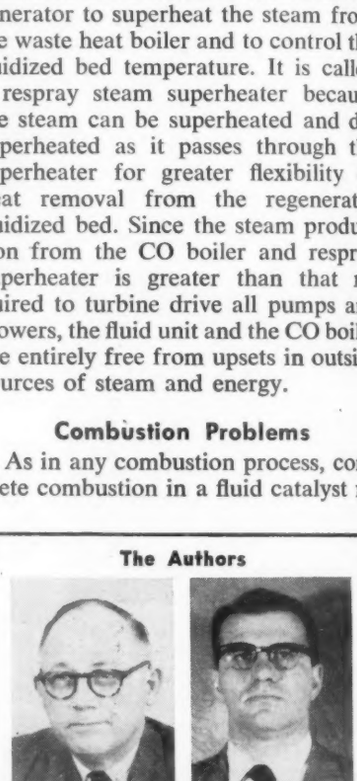
Heat input to the waste heat boiler comes from the sensible heat and the carbon monoxide heat of combustion of the regenerator exit gases, and from supplementary fuel required to burn the carbon monoxide to carbon dioxide. The waste heat boiler produces up to 330,000 lb per hour of 700 psig saturated steam, and is called the CO boiler because of its unique function of burning and recovering all of the combustion heat in the dilute carbon monoxide regenerator flue gas.

The respray steam superheater is immersed in the fluidized bed of the regenerator to superheat the steam from the waste heat boiler and to control the fluidized bed temperature. It is called a respray steam superheater because the steam can be superheated and desuperheated as it passes through the superheater for greater flexibility of heat removal from the regenerator fluidized bed. Since the steam production from the CO boiler and respray superheater is greater than that required to turbine drive all pumps and blowers, the fluid unit and the CO boiler are entirely free from upsets in outside sources of steam and energy.

Combustion Problems

As in any combustion process, complete combustion in a fluid catalyst re-

The Authors



O. F. Campbell N. E. Pennels

O. F. Campbell is combustion engineer for Sinclair Refining Company. He joined Sinclair in 1922 after graduating from the University of Michigan. He is a member of the American Petroleum Institute and U. S. Committee on Flame Radiation Research, ASME fellow and member of the ASME committee on Air Pollution Controls.

N. E. Pennels has been assistant combustion engineer of Sinclair Refining since 1952. After graduating from Michigan State College in 1947, Pennels joined Sinclair as trainee in the research and development department. He spent four years as engineer in the technical service department of Sinclair, Wyoming refinery and one year as project engineer on Sinclair's Houston refinery expansion program.

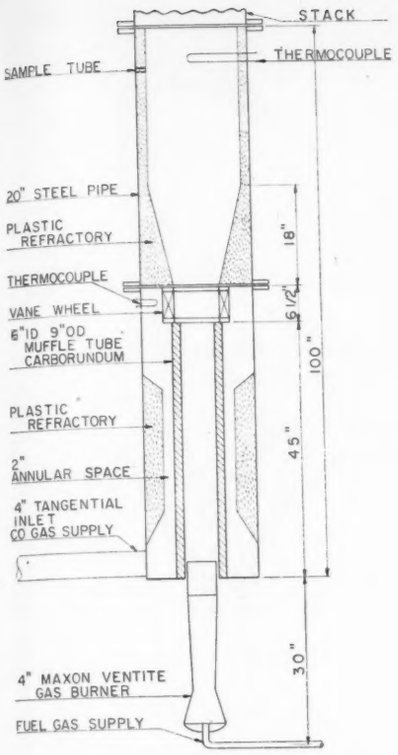


FIG. 2. Elevation drawing of experimental CO burner at Sinclair's Marcus Hook, Pennsylvania, refinery.

generator is primarily a function of time, temperature, turbulence, and excess oxygen. The catalyst is an added factor that retards complete combustion. Primary factor leading to CO production, however, is the low regenerator bed temperature. It must be remembered that the regenerator is designed primarily to restore the cracking activity of catalyst by burning off the carbonaceous cracking deposit of carbon and hydrogen (coke). As cracking catalyst is deactivated by sintering at high temperatures the regenerator temperature is usually limited to 1100 F for synthetic catalyst and 1070 F for natural catalyst. Excess oxygen is ordinarily very low due to the cost of compressing the regenerative air to about 20 psig. This factor would make it highly desirable to have an even higher carbon monoxide production since carbon dioxide requires twice as much oxygen as carbon monoxide.

Pilot Plant

The main problem in developing a waste heat boiler to recover the combustion heat of the carbon monoxide regenerator flue gas was to establish whether there were economical conditions of time, temperature, turbulence, and excess oxygen at which approximately 15 Btu per cubic foot CO bearing gas would complete combustion. Due to the low CO content, it was realized that thorough mixing with air at a temperature higher than that of the gas available from the regenerator was required.

The problem was investigated using a small pilot unit (Fig. 2), which was installed on Sinclair's fluid unit at Marcus Hook, Pennsylvania. The pilot unit was designed in February, 1950 and put into operation in June, 1950. The pilot unit was designed to raise the temperature of the flue gas by firing auxiliary fuel gas with sufficient excess air to supply excess oxygen to the CO gas. The vane wheel insured intimate mixing of the CO gas and the auxiliary fuel and air. Operation of this pilot unit proved that the CO bearing gases could be completely burned with 10 to 20 per cent excess oxygen in the exit flue gas and thorough mixing at a temperature above 1450 F. With this proof that the low Btu CO gas could be completely burned under reasonable operating conditions, the development of a commercial design to substantially simulate the pilot unit began.

CO Boiler Design

Basic premises for the CO boiler design were:

(1) The unit must completely burn all the CO in the regenerator flue gas.

(2) The design must be such that the capital cost and the operating cost could be justified by the fuel savings.

The pilot plant work had shown that with thorough mixing, the very dilute CO-bearing gas could be burned completely with low excess oxygen at a reasonable temperature level. Economics dictated thorough mixing for the commercial unit to insure complete combustion with minimum auxiliary air. The other important decision was whether the combustion chamber should be a water-cooled or a refractory furnace. The water-cooled furnace offered a lower capital cost for the combustion chamber. However, the heat absorption from the combustion chamber increased the auxiliary fuel requirements, thereby requiring a larger boiler which compensated for the added cost of the refractory combustion chamber. The refractory furnace offered minimum auxiliary fuel consumption with maximum certainty of maintaining combustion temperature at a reasonable cost.

With the decision that a refractory primary combustion chamber was preferable, the mixing problem was studied. Several ideas were examined. The method which seemed to offer the best mixing with the simplest equipment was to inject the CO gas into the primary furnace tangentially through several inlet ports at different levels. This would set up a swirling action to mix thoroughly the CO gas with the auxiliary fuel and air which would be

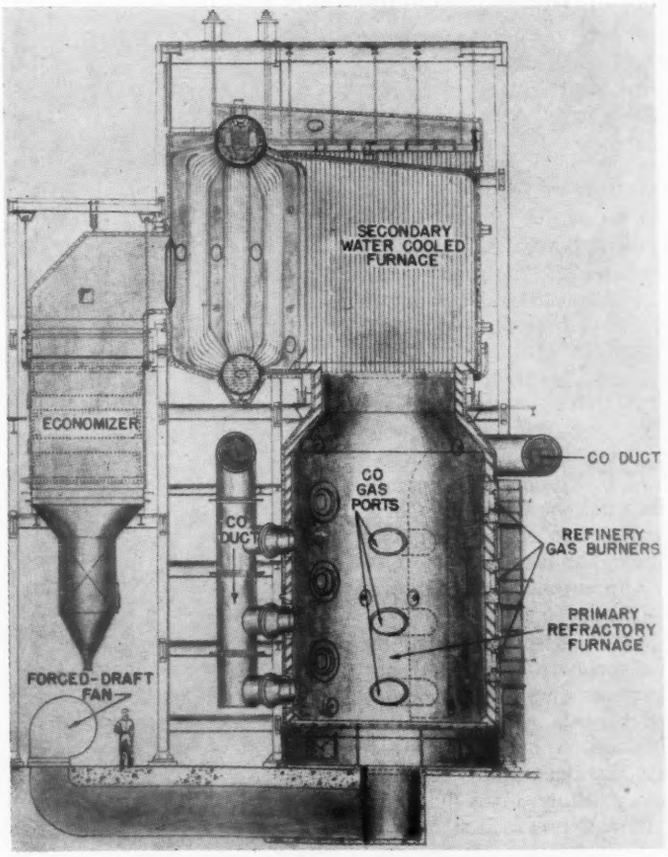


FIG. 3. Elevation drawing of CO boiler shown in Fig. 1.

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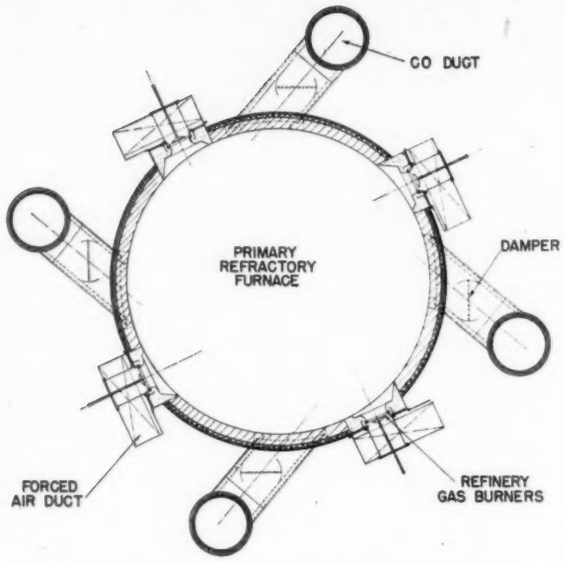

FIG. 4. Plan view of primary CO furnace.

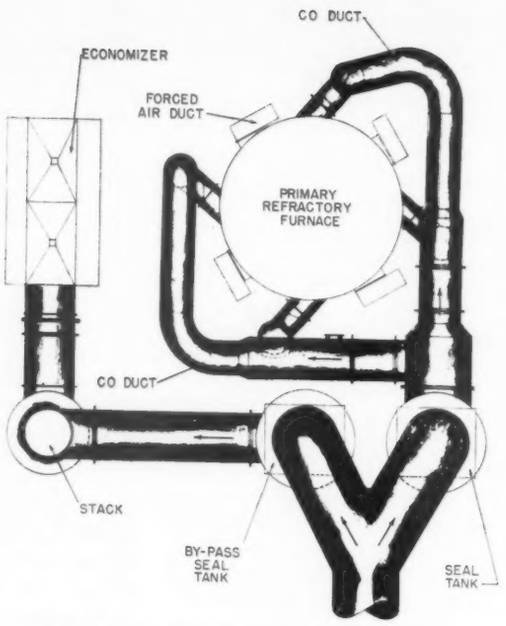

FIG. 6. Plot plan of complete CO burner installation.

fired through several burners located at different levels.

To be sure that the furnace would completely burn the dilute CO gas, it was decided to fire sufficient auxiliary fuel to raise the gases to approximately 1450 F without taking credit for the heat of combustion of any CO. The CO combustion heat would raise the temperature above 1450 F and provide a safe design and operating margin. Once the low Btu CO gas was completely burned, the problem of recovering the heat could be easily solved by a conventional water tube boiler and economizer.

CO Burner Design

With this background of experimental work and basic design, Sinclair management approved the construction of a CO boiler for the fluid catalytic cracking unit to be built at its Houston, Texas, refinery. In May, 1951, C. F. Braun and Company was chosen as the prime contractor for the fluid unit and The Babcock and Wilcox Company was chosen as the CO boiler manufacturer. With C. F. Braun and Company and The Babcock and Wilcox Company, the final design of the CO boiler was developed. The details of the CO boiler and its appurtenances are shown in Figs. 3, 4, 5, and 6.

The CO boiler consists essentially of a pressurized primary cylindrical refractory furnace and a secondary water-cooled furnace with an economizer. It includes a bypass arrangement so that the boiler may be shut down without shutting down the fluid unit. Even though pressurized boilers were in their early stages of development at the time of the design and Sinclair had no experience with pressurized furnaces, the very nature of the CO boiler dictated pressurized operation. The CO gas was already under pressure. The great volume of low Btu gas made induced draft operation excessively expensive.

Final design of the primary furnace was a cylindrical refractory furnace designed for operation up to 2500 F. This high temperature was selected so that the boiler could be fired with high excess air to produce 220,000 lb per hour of steam with no CO gas for the startup and shutdown periods of the fluid unit. CO gas was injected through 12 tangential inlet ports symmetrically situated with four ports at three different levels. Twelve auxiliary fuel burners were symmetrically located with four burners at each of three levels. The top level of burners was located above the top level of CO ports so that the CO bearing gas would have to pass through a top level of fire to leave the primary furnace.

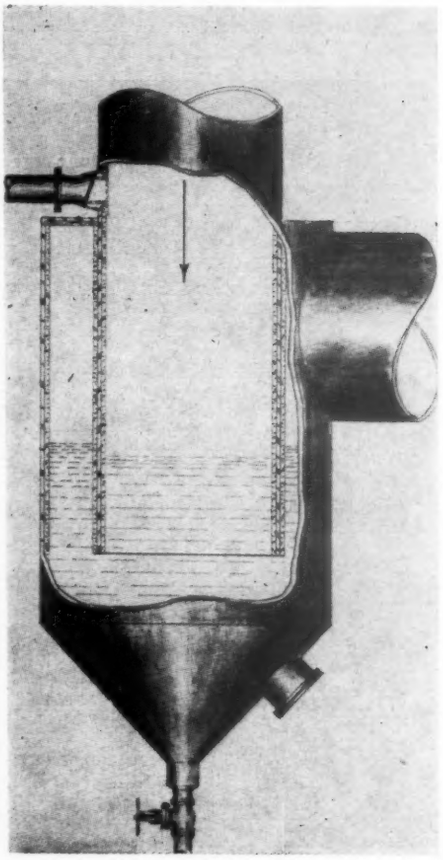

FIG. 5. CO burner water seal tank.

The secondary furnace is a conventional water tube single pass boiler. The arrangement of the top supported secondary furnace over the bottom supported primary furnace required a water seal to provide for the downward expansion of the secondary furnace and the upward expansion of the primary furnace. The seal is shown in Fig. 3.

To insure continuous operation of the fluid unit, a CO gas bypass system was designed. Fig. 6 shows that the CO gas from the regenerator may pass through a water seal tank to the boiler or through a bypass seal tank directly to the stack. Fig. 5 is a drawing of a seal tank with the water seal established. When the water is drawn out the CO gas passes down through the internal pipe, up the annular space and out the side duct. A multi-vane damper (not shown) is installed above the seal pot to provide partial closure so that the water seal may be established. The small pipe off the side of the inlet duct was provided to bleed off the gas by-

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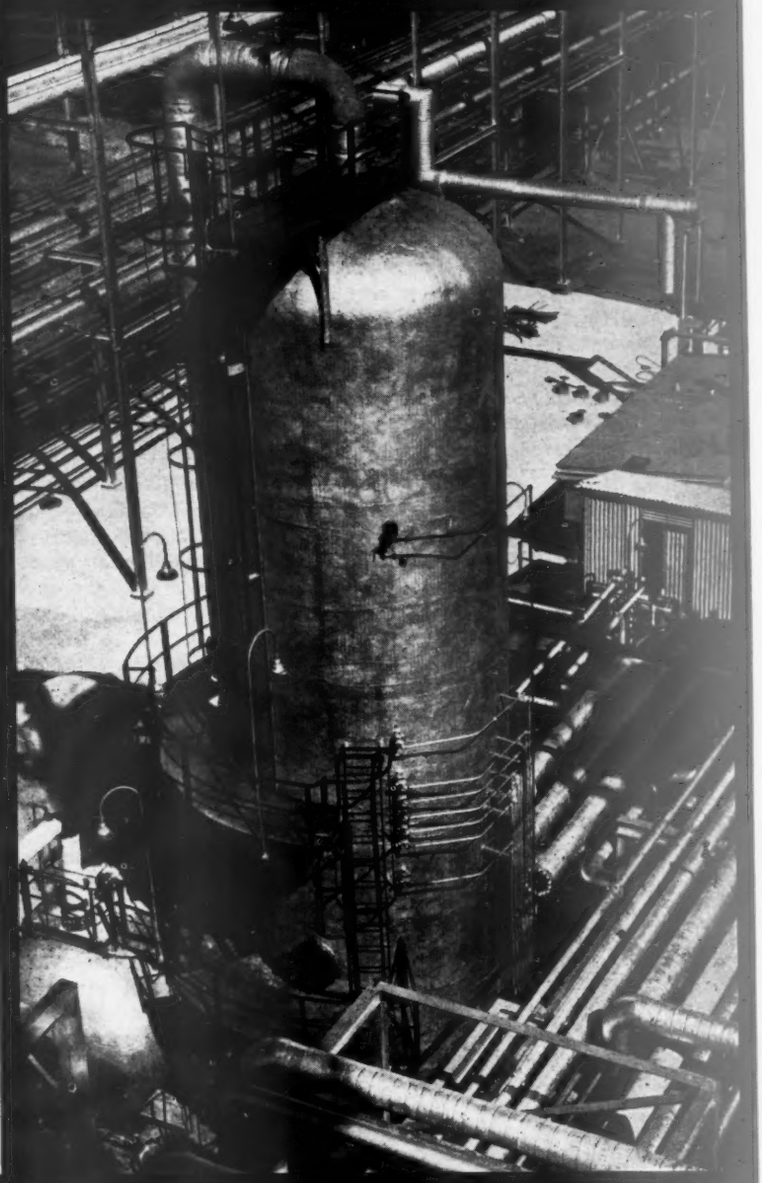

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passing the damper and make the water seal easier to establish. Operation has shown that it was not required.

Boiler feedwater for the CO boiler is condensate from the vacuum surface condenser for the fluid unit turbine drivers and hot lime-synthetic resin treated water from the main boiler house. A deaerating feedwater heater provides final deaeration and feedwater storage.

All controls for the CO boiler are situated at the fluid unit main control panel. The boiler feed pumps are pressure controlled by throttling the turbine steam with provisions for starting up and shutting down either pump from the board. The pumps are protected from low flow seizing by automatic low flow recirculation. The controls include three element feedwater control and automatic combusion control of the auxiliary fuel and air to control the primary furnace temperature. The boiler feed pumps and the forced draft fan are turbine driven and the controls are pneumatic to make operation free from power failure.

Boiler Operation

The CO boiler was brought on stream in October, 1953 with the new fluid unit. At this writing the CO boiler has been in operation for more than two months. The unit has been entirely successful producing over 300,000 lb per hour of 700 psig steam, while burning approximately 110,000,000 Btu per hour of auxiliary fuel. Combustion of the CO bearing gas has been complete.

Tables 1 and 2 summarize four performance tests made on the CO boiler during November, 1953. Reference to Table 1 shows steam production varied from 303,900 to 315,000 lb per hour. The 990 F CO-bearing gas from the regenerator varied from 650,000 to 679,000 lb per hour. CO content on the total gas was 4.8 volume per cent. Complete combustion was obtained with a primary furnace temperature of 1775 F to 1825 F with an oxygen content of 2.5 to 2.7 volume per cent in the total boiler exit flue gas.

Reference to Table 2 shows a total heat input to the CO boiler of approximately 430,000,000 Btu per hour. Of this, approximately 180,000,000 Btu per hour is the sensible heat of the CO gas, 140,000,000 Btu per hour is the combustion heat of the CO, and 110,000,000 Btu per hour is the auxiliary fuel and air. Thus, 320 million Btu per hour or 74.5 per cent of the heat input is waste heat. Table 2 includes heat balances of both the gas side and the steam side of the CO boiler. The steam side indicates a higher heat absorption than the heat given up by the gas side in all cases. The difference varies from 0.4 per cent to 3.3 per cent. It is felt that this is a good check. A mistake of 0.1 per cent in the Orsat analysis for the CO content of the regenerator flue gas is equivalent to 2,500,000 Btu per hour.

There were several interesting developments in the initial operation of the CO boiler. The tangential entry of the CO gases produced the desired mixing as evidenced by the complete combustion of the CO at 1800 F with 2.6 per cent oxygen in the flue gas. The swirling action was more pronounced than expected, producing a cyclonic effect which increased the pressure at the face of the furnace to as much as 8 in. of water pressure above the pressure in the center of the primary furnace. The pressure in the center of the primary furnace was 3 to 4 in. water pressure less than the pressure in the secondary furnace. The turbine-driven forced-draft fan had to be speeded up to provide the necessary static pressure to force the auxiliary air through the cyclonic wall of gases.

Soot Blowers Clean Tubes

One other interesting feature is the use of Diamond I. K. retractable soot blowers to keep the boiler and the economizer clean. During the design stages there was considerable discussion as to whether the catalyst fines would collect on the boiler tubes. It was decided to install 12 I. K. retractable soot blowers, 8 in the boiler passes and 4 in the economizer. Operations have shown that the catalyst fines definitely collect on the boiler and economizer tubes. The soot blowers have been thoroughly successful in keeping the tubes clean when used on a once-per-shift cleaning schedule. There has been no collection of catalyst fines in the primary furnace.

Control of the CO boiler has been very easy. Automatic control of the primary furnace temperature has, however, proved unnecessary. The quantity, temperature and CO content of the regenerator flue gas are so consistent that the pirmary furnace temperature does not have enough variation to permit automatic control. As a result, boiler operation to date has been on manual control. High and low temperature alarms are provided to warn of abnormal conditions.

Respray Steam Superheater

Prior to the decision to install the respray steam superheater in the regenerator fluidized bed, test work was conducted to determine the heat transfer rate and the feasibility of such an installation. Test work consisted of inserting a one-inch water-cooled bayonet or probe into the fluidized bed of an existing fluid unit. The quantity of circulating water was weighed, the water temperature rise was taken and with a known heating surface and the temperature of the fluidized bed, a heat transfer rate was established, which was reasonably close to the data available in the literature.

Before operating the Houston respray steam superheater, Sinclair had obtained valuable experiences in fluidized bed heat transfer at their Wood River Refinery. When Sinclair purchased their Wood River Refinery from Wood River Refining Company, operating equipment included a heat bal-

TABLE 1. Carbon monoxide boiler, test data.

Test number	1	2	3	4
CO bearing gas				
Quanity M lb/hr....	650.4	650.9	679.2	678.6
Temperature °F.....	990	990	993	993
Composition mol %				
Carbon dioxide.....	8.2	8.1	7.8	7.8
Carbon monoxide...	4.8	4.8	4.7	4.9
Oxygen.....	4.5	4.5	4.5	4.5
Nitrogen.....	67.5	67.4	67.7	67.8
Water vapor.....	15.0	15.2	15.3	15.0
Total.....	100.0	100.0	100.0	100.0
Auxiliary fuel (natural gas)				
Quantity M lb/hr..	4.75	4.75	4.63	4.63
Temperature °F....	73	76	78	80
Higher heating value Btu/lb.....	23,186	23,178	23,391	23,351
Auxiliary air				
Quantity M lb/hr...	108.0	103.7	106.7	111.4
Moisture M lb/hr...	1.6	1.5	0.5	0.7
Temperature °F.....	72	74	66	66
Fuel gas				
Quantity M lb/hr...	764.75	760.85	791.	795.33
Temperature °F.....	503	511	530	530
Composition mol %				
Carbon dioxide.....	12.3	12.3	12 0	12.0
Carbon monoxide...	0.0	0.0	0 C	0.0
Oxygen.....	2.6	2.5	2.6	2.7
Nitrogen.....	69.6	69.5	69.9	70.0
Water vapor.....	15.5	15.7	15.5	15.3
Total.....	100.0	100.0	100.0	100.0
Primary furnace temperature °F.....	1815	1825	1775	1775
Primary furnace pressure "H_2O.....	13.1	.1	13.1	13.0
Steam (saturated)				
Quantity M lb/hr..	305.7	303.9	315.0	313.2
Pressure psig.....	710	710	715	710
Boiler feedwater				
Quantity M lb/hr...	330.0	328.0	340 0	338.0
Temperature °F.....	235	235	235	235

TABLE 2. Carbon monoxide boiler, test heat balances million Btu/hour datum. 0 F.

Test number	1	2	3	4
Gas side				
Heat in				
CO bearing gas				
Sensible heat.....	175.26	175.38	183.95	183.53
Combustion heat..	135.40	137.60	141.39	144.09
Auxiliary fuel				
Sensible heat.....	0.16	0.17	0.18	0.18
Combustion heat..	110.16	110.12	108.28	108.09
Auxiliary air				
Sensible heat.....	1.93	1.90	1.69	1.77
Total.....	422.91	425.17	435.49	437.66
Heat out				
Fuel gas.....	113.18	114.34	122.42	123.76
Radiation (0.5%)...	2.11	2.13	2.18	2.19
Total.....	115.29	116.47	124.60	125.95
Total heat absorbed.....	307.62	308.70	310.89	311.71
Steam side				
Heat in				
Feedwater.....	67.08	66.68	69.12	68.72
Heat absorbed.....	312.00	309.90	321.47	319.62
Total.....	379.08	376.58	390.59	388.34
Heat out				
Steam.....	367.02	364.60	378.16	376.03
Blowdown.....	12.06	11.98	12.43	12.31
Total.....	379.08	376.58	390.59	388.34
Total heat absorbed				
Gas side.....	307.62	308.70	310.89	311.71
Steam side.....	312.00	309.90	321.47	319.62
Difference.....	4.38	1.20	10.58	7.91
Per cent difference..	1.4	0.4	3.3	2.5

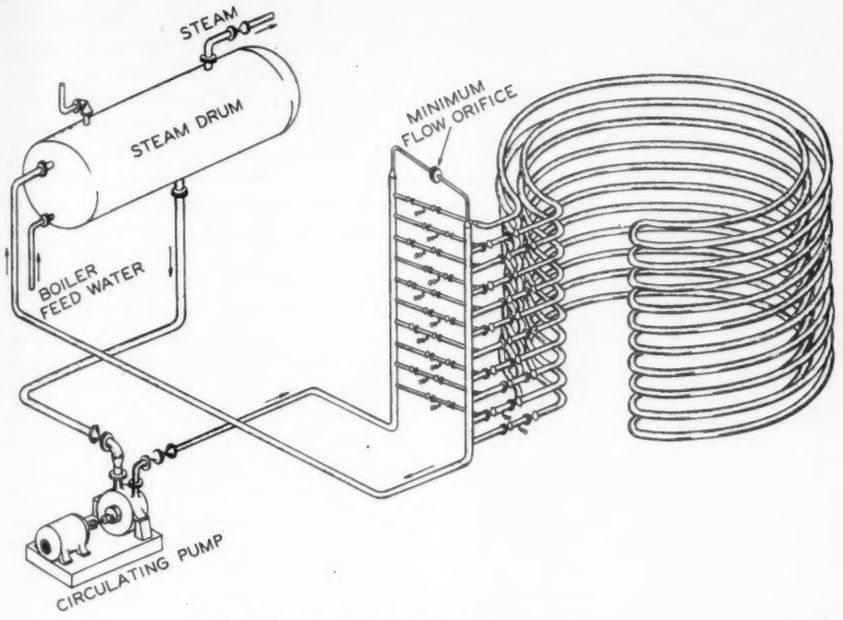


FIG. 7. Forced circulation boiler for fluid regenerator temperature control, Sinclair's Wood River refinery.

ance type fluid unit. To increase capacity and improve yields and obtain better control of cracking conditions, a forced circulation boiler was designed with the heating surface immersed in the regenerator fluidized bed. This was the only practical way to remove heat from the regenerator since the regenerator was so close to the ground that there was no room to use a conventional recycle boiler. Fig. 7 shows the general arrangement of the Wood River forced circulation boiler which was placed in operation November 12, 1952. Operation of the Wood River unit substantiated the known data which was later confirmed on the new Houston fluid unit. This boiler is equipped with 10 coils having a total heating surface of about 600 sq ft. Heat absorption rates of approximately 50,000 to 60,000 Btu per square foot per hour have been obtained with a temperature differential of approximately 700 F. The heat extraction can be controlled by only 10 per cent increments by cutting coils in or out of service, one coil at a time. At the end of one year's continuous service, no repairs were required on the Wood River forced circulation boiler coils.

Process. One of the operating variables to be controlled on a fluid unit is the regenerator bed temperature. The burning of coke from the catalyst releases tremendous quantities of heat. Part of this heat passes out with the products of combustion to the CO boiler. Another part is removed by catalyst circulation from the regenerator to the reactor since the catalyst enters the regenerator at about 900 F and leaves at about 1100 F. Balance of the heat must be removed by other means or the temperature in the regenerator would rise to a temperature well above 1100 F. This would sinter and deactivate the catalyst. To remove this excess heat and make it possible to control the regenerator bed temperature, this unit is provided with four heat exchange coils, in series, immersed in the bed. The general arrangement of the coils in the fluidized bed is shown by Figs. 8 and 9. The saturated steam from the CO boiler passes through these coils and by removing the excess heat from the regenerator the steam is superheated.

Greater Heat Transfer Rate

Just as the CO boiler is a "first" so is this method of controlling the fluidized bed temperature by superheating steam a "first." Actually, it is merely a heat exchanger in which the coils are the tubes and the regenerator is the shell. The coils are constructed very similar to a superheater on a fired boiler. The superheater material is "Croloy 5" and has an indefinite life under conditions inside the regenerator with no steam flow through the coils. The general design of the superheater is shown by Fig. 10. The difference between this type of superheater and a superheater in a boiler is the medium surrounding the coils. In a boiler the hot flue gases flow past the tubes, whereas these coils are immersed in the fluidized bed. The superheater tubes are bombarded with very fine hot catalyst particles and the heat transfer rate is greater than in a conventional boiler. *The heat transfer rate in the fluidized bed as compared with a steam superheater of a fired boiler appears to be from five to seven times greater for the same temperature differential.* It appears that consideration should be given to this method of superheating steam for public utility stations that use reheat.

The ideal design for this system would be to have an exact balance between the quantity of steam available and the quantity of heat to be removed from the regenerator so that when the steam was passed through the coils it would remove the desired amount of heat from the regenerator and the steam would be superheated to the desired temperature. This, however, is not the case. For normal operation the quantity of heat to be removed from the regenerator is greater than is required to superheat the available steam from the CO boiler to the desired temperature of 750 F. Therefore, a system of desuperheating stations has been provided so that the steam can alternately be superheated and desuperheated. The schematic flow diagram of the respray steam superheater is shown by Fig. 7. With these superheaters, both the regenerator bed temperature and the steam temperature may be controlled over a wide range of steam flows and required heat removals from the regenerator bed.

Superheater Does Double Duty

The respray steam superheaters perform two functions — that of controlling the regenerator bed temperature and that of superheating the steam from the CO boiler. The regenerator bed temperature is controlled at any point below a maximum of 1100 F and the superheater steam temperature of 750 F. Provisions have been made to do both automatically.

Saturated steam from the CO boiler passes through the superheater coils or through the bypass around the coils. The more steam that flows through the coils the more heat will be removed from the bed. Based on this fact, the regenerator bed temperature controller varies the quantity of steam passing through the coils by controlling a motor valve in a bypass steam line around the coils. Thus, the flow through the coils is indirectly controlled rather than directly controlled by a valve in the line to the coils. This is the automatic control of the regenerator bed temperature.

From the schematic flow diagram of the respray steam superheater, it is noted that there are desuperheating stations at the inlet and outlet of each section of the superheater. At the outlet of the first, second, and third coils, (the desuperheaters at the inlet of the first coil and the outlet of the fourth coil are for different purposes) desuperheating stations have been provided to spray the superheated steam with condensate. This reduces the temperature of the steam and increases the temperature differential between the steam and the catalyst bed. As the condensate is vaporized to steam, it also increases

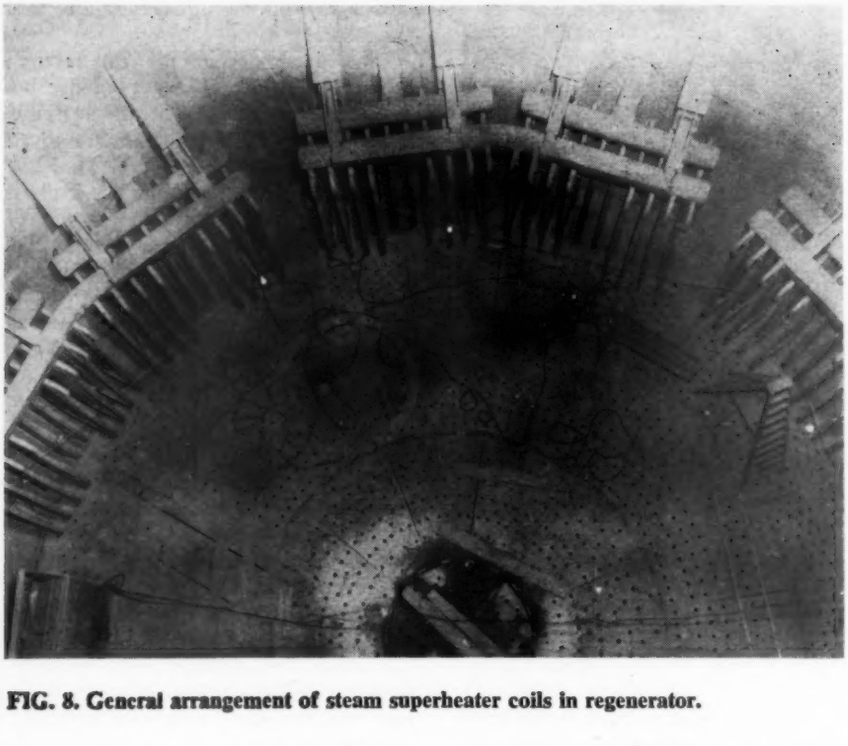


FIG. 8. General arrangement of steam superheater coils in regenerator.

the quantity of steam flowing to the following coils. Both the reduced steam temperature and the increased quantity of steam make it possible to remove more heat from the regenerator. It is thus seen that if the regenerator bed temperature controller will not hold the bed temperature by varying the bypass steam because conditions are out of its range, conditions can be brought into range by spraying condensate into the superheated steam at these desuperheating stations.

After the steam passing through the coils and the bypass are mixed, the blend temperature must be 750 F. This is controlled by a temperature controller that can vary the condensate flow to the desuperheater at the outlet of No. 4 coil, to control the mixture of coil steam and bypass steam at 750 F. This steam temperature controller can also vary the condensate flow to the desuperheater at the inlet of No. 4 coil between certain limits. Thus, the control of the final steam temperature is obtained by controlling the temperature of the superheated coil steam so that it will blend with the bypass steam to a final temperature of 750 F. The controller is so set that it will first increase or decrease the condensate to the outlet of No. 4 coil.

If, however, the maximum quantity of condensate to this desuperheater will not control the blend temperature, the temperature controller will then start condensate to the desuperheater at the inlet of No. 4 coil. The temperature controller at the inlet of No. 4 coil is designed to prevent this condensate from lowering the temperature of the steam to No. 4 coil below a minimum of 530 F. The minimum temperature of 530 F was arbitrarily chosen as being a satisfactory control point to prevent ever reducing the temperature to steam saturation temperature which is 505 F at 700 psig. This was done to prevent condensate evaporation in the coils where evaporation would cause any soluble salts that might be present to be deposited. When conditions are such that the temperature controller on No. 4 coil inlet overrides the main steam temperature controller and the steam temperature is not under control, then the quantity of condensate to the other desuperheater must manually be increased to bring the temperature under control.

It was noted previously that the desuperheater on the inlet of No. 1 coil was for a different purpose than the other desuperheaters. During normal operation this will not be in use since the steam from the CO boiler is already saturated steam. In the event that it is necessary to operate the fluid unit with the CO boiler shutdown, however, the steam for bed cooling is the plant 550 psig steam that has already been superheated to 750 F. During this period the first desuperheater would be used to desuperheat this steam to 530 F and the other desuperheaters would be adjusted in the same manner as for normal operation.

The operation of the respray steam superheater is controlled entirely from the main fluid unit control board. The desuperheating or respray water is condensate which comes from the main condenser for the condensing turbines of the fluid unit. The condensate is heated to approximately 240 F in a separate section of the main CO boiler feedwater heater and is pumped by turbine driven desuperheating pumps to the desuperheating stations. These turbine driven pumps are automatically controlled from the main control board and can be taken in or out of service from the main control board. In the event that these desuperheating pumps fail, desuperheating water can be taken from the main boiler feed pumps for the CO boiler. This is done automatically by an automatic cut-in valve when the desuperheating water pressure falls below a set pressure. Only in an extreme emergency will boiler feedwater be used for desuperheating because the soluble salts in the boiler feedwater would foul the superheater.

Table 3 gives the results of actual

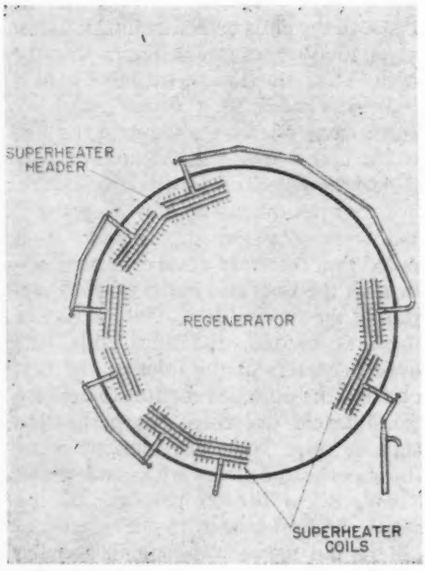


FIG. 9. Drawing of superheater coils shown in Fig. 8 photo.

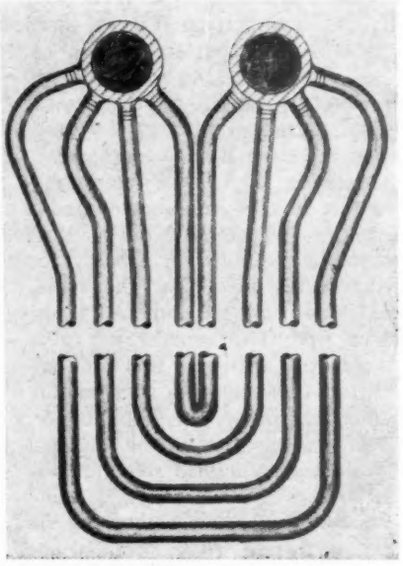
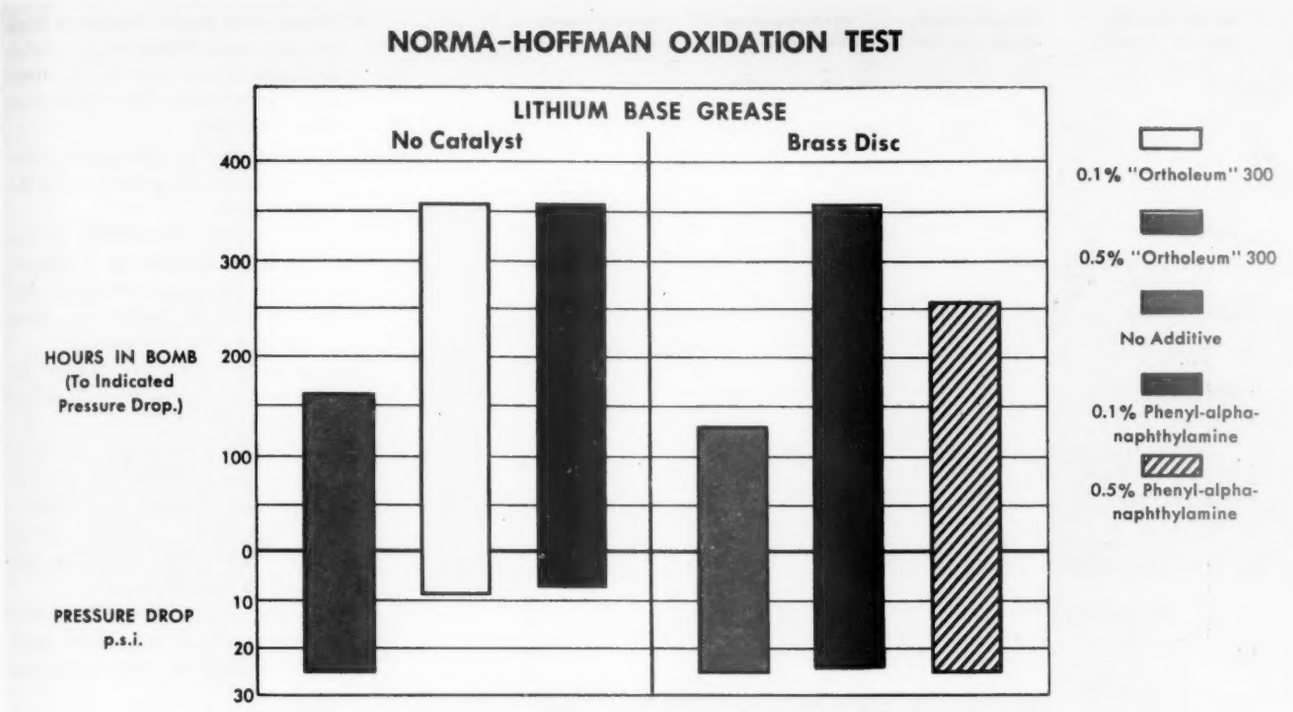


FIG. 10. Section of a superheater coil, showing design principle.



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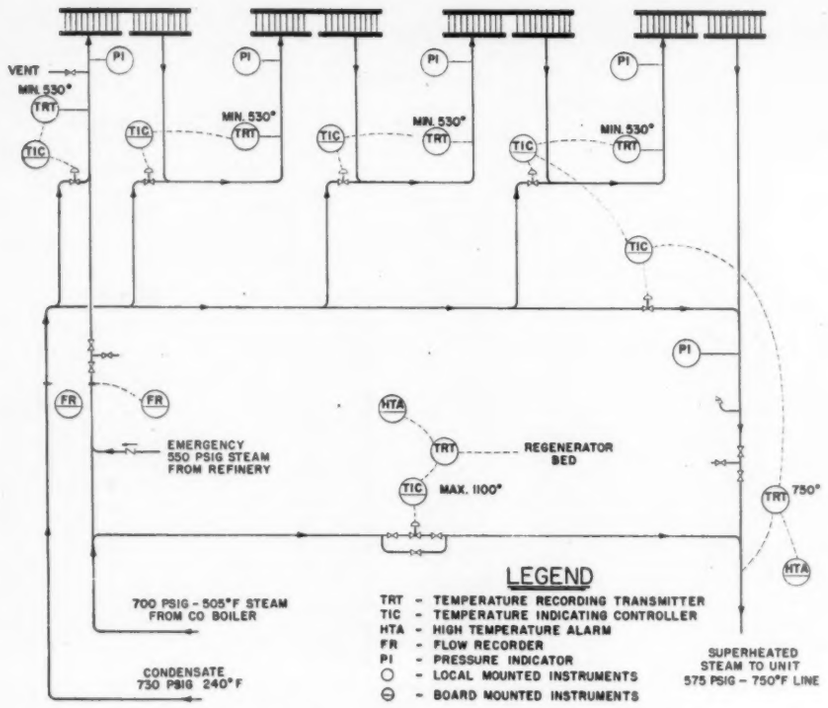


FIG. 11. Schematic diagram of the respray steam superheater system.

field tests. It is noted that a transfer rate of approximately 70 was obtained. Design was based on a transfer rate of 67.5. Data in the table show that the maximum heat absorbed to date was approximately 169,000,000 Btu per hour. The amount of heat required to superheat the steam produced from the CO boiler to 750 F would be approximately 80,000,000 Btu per hour. Therefore, the heat absorbed by the respray steam superheater will vary between approximately 80,000,000 Btu per hour and 170,000,000 Btu per hour. It will depend upon the amount of heat that is required to be extracted from the regenerator bed to hold the regenerator bed temperature at its desired level.

Operations to date have been better than expected. The CO boiler produces steam at substantially a constant pressure and rate and under these conditions even manual control of the regenerator bed temperature is satisfactory.

TABLE 3. Fluidized bed respray steam superheater. Test data.

Test number	1	2	3	4
Steam to superheater				
Quantity M lb/hr...	305.7	303.9	315.0	313.2
Pressure psig.....	710	710	715	710
Temperature °F.....	507	507	508	507
Respray condensate to superheater				
Quantity M lb/hr..	81.0	87.0	94.0	87.0
Temperature °F....	235	235	235	235
Superheater steam				
Quantity M lb/hr...	386.7	390.9	409.0	390.2
Pressure psig.....	540	540	540	540
Temperature °F.....	750	750	755	760
Total heat absorbed M Btu/hr.....	150.9	157.6	169.1	161.6
Regenerator bed temperature °F.....	1067	1066	1059	1058
Log mean temperature difference °F.....	362	368	386	365
Effective surface ft²...	6000	6000	6000	6000
Overall heat transfer rate Btu/hr/ft²/°F...	69.3	71.3	72.8	73.7

NOTE: M .. 1,000,000.

Conclusions

Installation of the combination CO boiler and respray steam superheater is the natural outgrowth of Sinclair's general policy to operate fluid units on a non-heat balance basis and conservation of fuel and electric energy. This combination allows for maximum flexibility of operation of a fluid unit to produce more and better products and at the same time provides maximum conservation of fuel.

In addition to the above, there are several other advantages such as:

(1) Being independent from outside sources of steam and energy during operation, shutdown or startup.

(2) Complete control of steam production for fluid unit is under supervision of fluid operators.

(3) Steam can be produced at high pressure and temperature, which decreases the steam requirements per horsepower for fluid unit prime movers.

(4) Prevents the CO gas from escaping and possible pollution of the atmosphere.

(5) Precludes the possibility of unburned hydrocarbons or malodorous gases, or other gases that may cause air pollution, from escaping to the atmosphere.

(6) Conditions the flue gases for subsequent removal of particulate matter.

(7) Produces excess steam for other refinery uses and reduces the output of the refinery fired boilers.

(8) Eliminates the necessity of an added fired boiler to start up and shutdown the fluid unit.

(9) The cost of the CO boiler and its appurtenances is no greater than a fired boiler of equivalent output.

Successful operations of the CO boiler and the respray steam superheater have been extremely gratifying experiences which are typical of progress in a competitive industry. Competition requires maximum product quality and quantity with minimum operating expense. The CO boiler to minimize fuel consumption by utilizing waste heat, and the respray steam superheater coils to provide optimum catalytic cracking are new tools to meet these goals.

Acknowledgment

The writers acknowledge the following engineers for their assistance in original design, drawings, photographs, construction, and operation of the CO boiler and the respray steam superheater: H. S. Spaulding, J. Bowen, M. Bason, C. F. Braun; F. S. Nolte, C. L. Marquez, E. H. Manny, E. Durham, L. W. Hayward, J. Knoblesdorf, L. G. Troutman, Babcock and Wilcox; W. S. Gullette, H. C. Kuhn, W. H. Decker, D. A. Stewart, R. S. Cooper, R. Y. Rankin, W. F. Shippani, Sinclair Refining.

* * *

More Lube Additives by Monsanto

Monsanto Chemical Company is constructing facilities to increase production of detergent additives for lubricating oils, it was announced by John W. Newcombe, petroleum chemicals sales manager for organic chemicals division.

The added capacity, which will approximately double the company's production of detergent-dispersant oil additives, is being erected at the division's W. G. Krummrich plant at Monsanto, Illinois, and is expected to start up in September of this year.

The market for lubricating oil additives, latest figures indicate, will approach $110 million this year as compared with a little less than $25 million just after World War II.

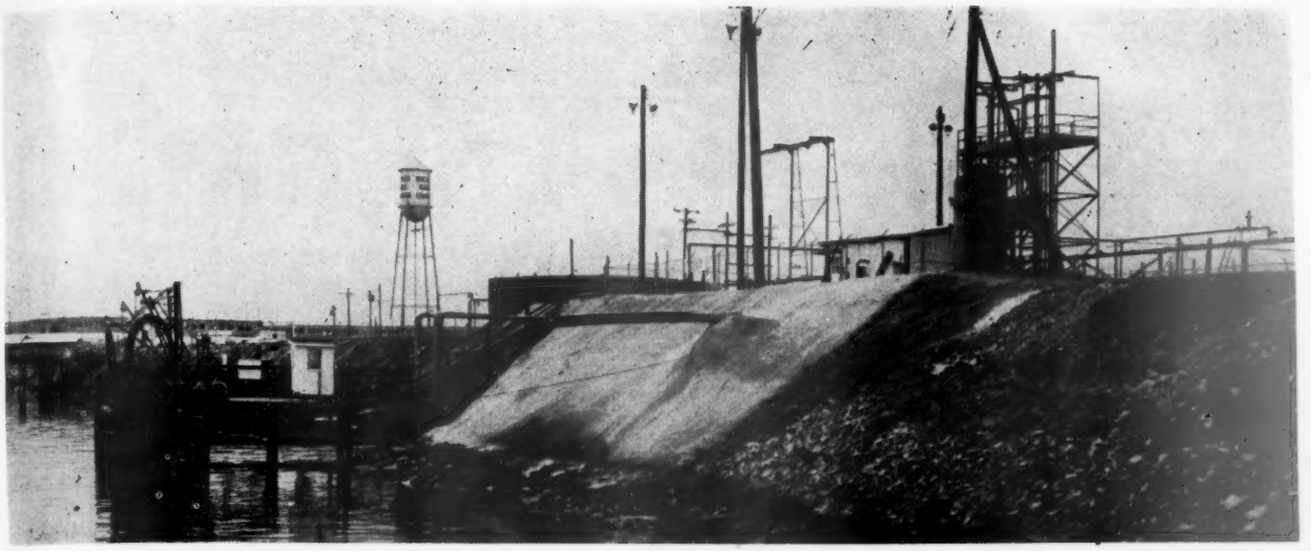


FIG. 1. View of finished reinforcement of the water-way bank at Eastern States' Houston, Texas, refinery No. 2.

Refinery Waterfront Maintenance—Repair Technique

Old "gunited concrete" method employed for a new purpose in repairing plant water-way banks

H. M. MARTIN*

RECENTLY, severe erosion on Eastern States Petroleum Company's Plant 2 waterfront necessitated quick repairs to prevent expensive damage to a shore installation.

A Tee-head dock had been built for the unloading of butane and a compressor and pumping station had been built near the bank edge of the dock. Erosion of the land by wave action between the dock and pumping station was greater than had been anticipated and the foundations of the pumping station were in danger of failing. The most obvious method of preventing this erosion was to drive sheet piling along the waterfront in the danger area. Estimates were made on this work and the cost was found to be out of line with the value of the dock itself. It was then decided to use an old refinery technique in repairing the damage. For many years it had been a standard practice to repair tank walls and tank roofs, large pipe and some structures by the application of gunited concrete. This method had proved satisfactory in the refinery and it was decided to try it on the waterfront.

First, a dragline was moved in and the slope of the bank was cut down to a 1 to 1 grade. Heavy concrete rip-rap in the form of old broken sidewalks and fragments of building walls were laid along the water's edge extending from slightly below low tide to an elevation of approximately 6 ft above low tide. Three by three mesh wire was entangled in the rip-rap and then the mesh was rolled up the slope. A trench 8 in. wide by 18 in. deep was cut about 4 ft back from the top edge of the bank and the wire mesh was rolled over the edge of the bank and the ends were turned down into the trench. Six by six wire mesh was also placed in the trench for additional reenforcement. The trench was then filled with concrete. Back of the trench a shallow drain ditch was provided to catch surface drainage from the surrounding area. This ditch drained to conventional catch basins which emptied into the bayou through a pipe outfall.

After the concrete in the ditch had set, the gunite crews moved on to the job and blasted Portland cement concrete into place through the wire mesh. The wire mesh was held approximately one inch off the ground by the use of small stones or brickbats and the concrete was shot through the mesh to a total thickness of approximately two inches. The guniting operation was carried down to the water's edge with the gunited concrete being shot into the rip-rap section. Fig. 2 gives a cross-section of the operation.

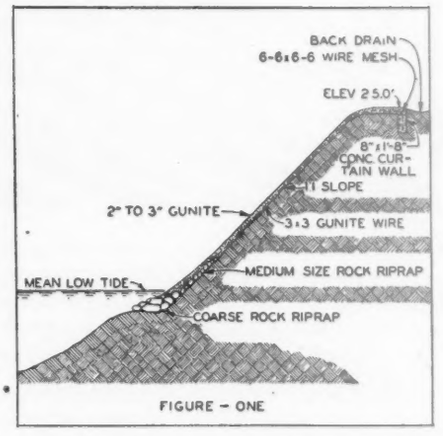


FIG. 2. Cross-section of bank repair, showing details of construction.

This method of protecting the waterfront has proved satisfactory. Since the installation of the protection there has been no trouble from erosion and the cost of the installation was much less than the estimated cost of sheet piling bulkhead. This is one example where the application of refinery techniques to other types of work has paid off with a generous saving. * * *

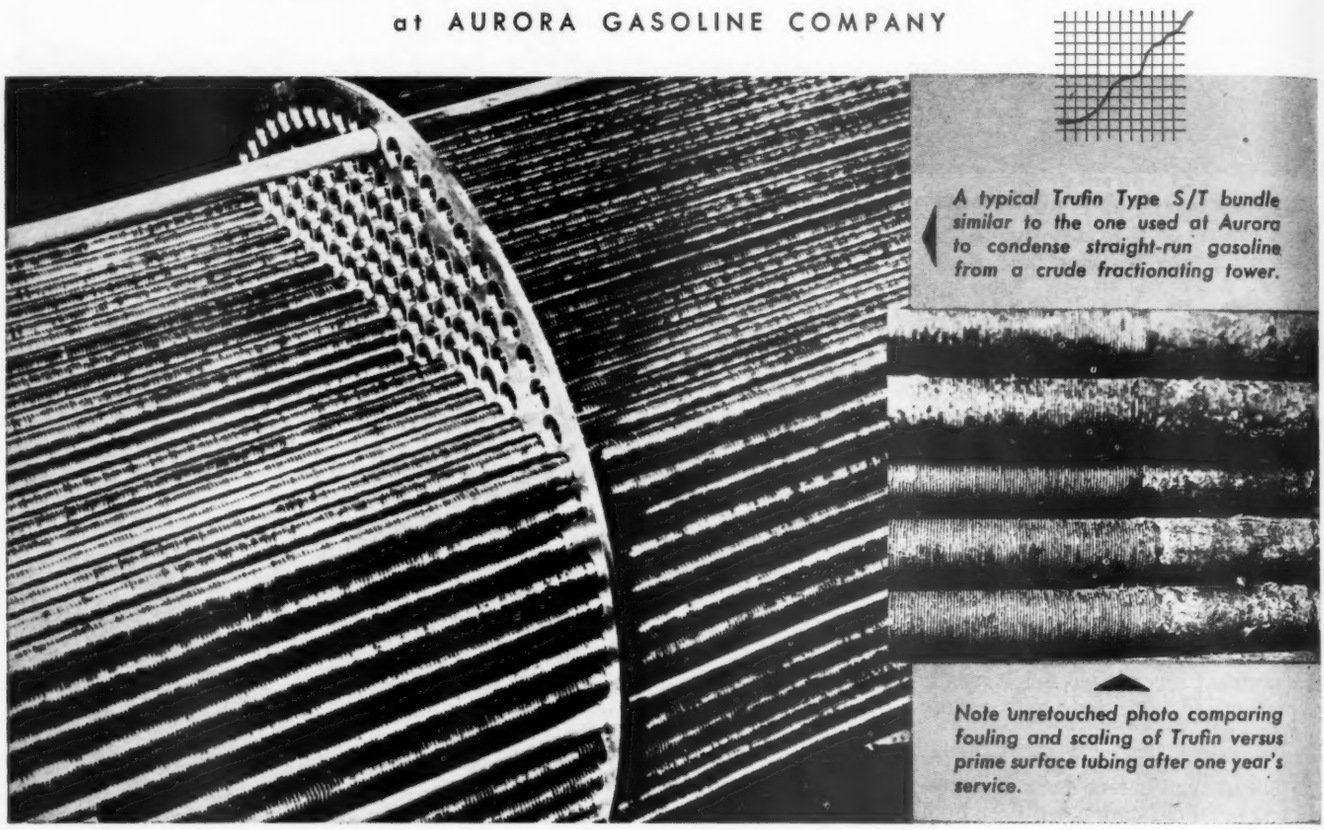
*Chief engineer, Eastern States Petroleum Company, Inc.

EXCLUSIVE

How RETUBING WITH Wolverine Trufin*
TYPE S/T

BOOSTED CONDENSING CAPACITY

at AURORA GASOLINE COMPANY



A typical Trufin Type S/T bundle similar to the one used at Aurora to condense straight-run gasoline from a crude fractionating tower.

Note unretouched photo comparing fouling and scaling of Trufin versus prime surface tubing after one year's service.

Increased production of an existing "stand-by" condenser at Aurora Gasoline Company, Detroit, Michigan called for the installation of additional condensing surface area. The stand-by unit—a small, prime-surface tube unit—was not originally designed for this kind of service.

Wolverine's Field Engineering Service suggested that the smaller condenser be retubed with Trufin Type S/T . . . an integral finned tube designed primarily for shell and tube units. Trufin was a natural choice simply because it packs so much condensing surface in a small area.

As a result, the stand-by unit—when retubed with Trufin—operated at the same heat duty as the larger prime-surface condenser originally designed for this service.

Full advantages of Wolverine Trufin are realized in units like Aurora's. When additional capacity or increased surface area is required—where costs must be reduced—Trufin can do an outstanding job.

Remember: Trufin is all one piece! Fins are extruded right from the tube wall. Trufin stands up under the shock of vibration, temperature changes, and pressures.

WHAT ABOUT YOU? If you have an under-surfaced heat exchanger—one that requires a bigger punch—you'd do best to consider Trufin, too. It's available in copper, inhibited admiralty, copper-base alloys, aluminum, stainless steel, electric welded steel, bi-metal. Write for your copy of Wolverine's Condenser Tube Book today! WOLVERINE TUBE DIVISION of Calumet & Hecla, Inc., 1439 Central Avenue, Detroit 9, Michigan.

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario.

*REG. U.S. PAT. OFF.

EST. 1916

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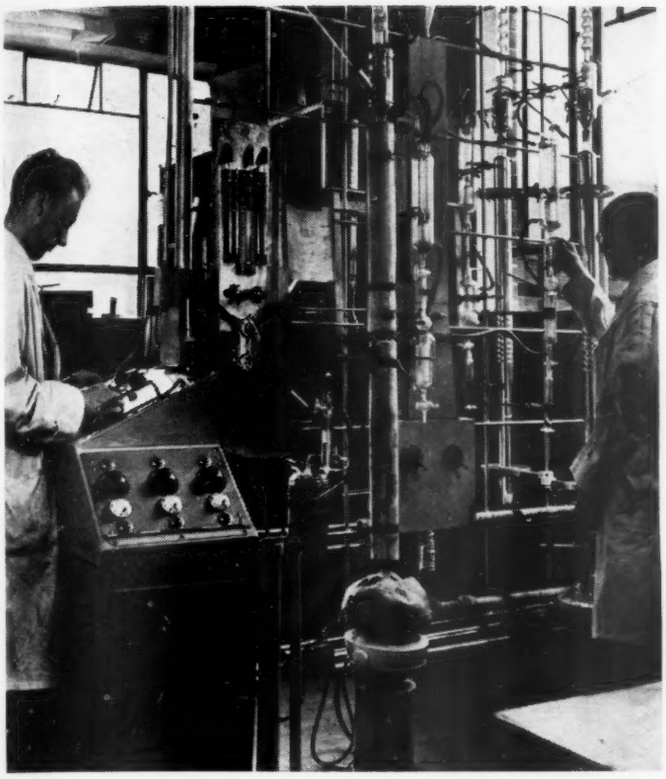
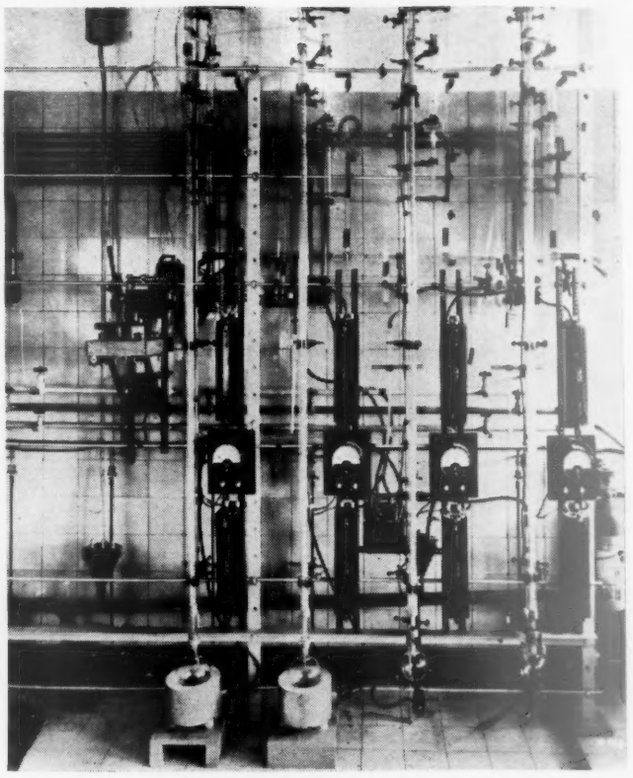


Glass vacuum distillation unit at technological laboratory at Shell Stanlow refinery, England.



Precision fractionating columns at Amsterdam laboratory.

Research and Development

Shell Activities Girdle the Globe

With large units in 11 locations, in America, Holland, England, Shell covers every field in petroleum, petrochemicals

V. S. SWAMINATHAN*

THE Royal Dutch-Shell Group has at its disposal one of the largest industrial research organizations in the world. Companies comprising it have in all 4000 persons directly concerned in carrying out scientific research work. The following figures of strength of personnel at various dates testify to the remarkably rapid growth of this crucial branch of activity of the Group: 1919—25; 1926—100; 1928—250; 1935—1000; 1939—2000 and since 1947—4000. They reflect the evolution of the petroleum industry from the technologically backward stage when oil for lamps still constituted the main product to the present period in which it supplies the community with all sorts of valuable products, some in enormous quantities, which must satisfy precise and exacting requirements. Annual outlay on research and development activities is of the order of $25,000,000.

Broadly speaking, the Group research activities fall into four categories: (1) Fundamental research on basic scientific facts, which is not only essential for the successful continuation of all research, but which also leads to the eventual introduction of totally new products or processes. (2) Exploration and production research, which studies new methods and equipment for seeking and winning oil from the earth. (3) Manufacturing research, which investigates problems connected with the conversion of crude oil into a multitude of products. (4) Applicational research, which aims at finding improved methods for using existing products or improved products to meet new conditions.

At present, scientific research work is carried on within the Group in 11 laboratories that may be classified thus: Three large units (Amsterdam, Emeryville, and Thornton) with staffs of about 1000 persons each. Four moderately large units (Delft, Wood River, Houston Exploration and Production, and Houston Process Research) with staffs from 140 to 200 persons. Four small units (Martinez Shell Oil, Martinez Shell Chemical, Wilmington and Modesto) with staffs from 40 to 70 persons. Some smaller units with a correspondingly limited sphere of operation have been left out of this tabulation. In recent years special attention

*European Correspondent.

EXCLUSIVE

A woman entomologist works on insecticides, etc., at Shell's Sittingbourne, England, agricultural research station.

In this irrigation canal in Egypt, research staff found that lining with bitumen practically eliminates seepage of precious water.

has been paid to the most effective coordination and integration of research work of all these laboratories.

In October, 1895, a small laboratory was set up by the Royal Dutch Petroleum Company in Delft which was transferred to The Hague two months later, and removed to Rotterdam in 1902 where it remained till the early part of 1914. Work at the time mainly consisted in the development and application of methods for the analysis and inspection of petroleum products. Great care is still being paid (a) to what physical and chemical characteristics of an oil product can best serve as criteria for technical and commercial serviceability or, as the case may be, for identification; and (b) to the development of methods and apparatus for the determination of such characteristics with the requisite degree of accuracy and reproducibility. Even at this early stage industrial research found its sphere of operation in the search for better products and manufacturing processes, and for new possibilities of utilizing products and processes. Thus the feasibility of manufacturing candles from paraffin wax and of improving the burning properties of oil were studied. In connection with the latter, the Edelenau process for removing undesirable components by extraction with liquid SO_2 was investigated in detail and its effectiveness confirmed. This process was applied for the first time in 1913 on an industrial scale in one of the Group refineries. Also, the progress made in distillation technique enabled a fraction rich in toluene to be produced from a gasoline from Borneo, which proved a godsend to the Allied cause during the first world war.

In February, 1914, the Group laboratory at Rotterdam was moved to Amsterdam. The structure then occupying the northern side of the harbor formed the nucleus from which the great research complex of the present Royal Dutch-Shell Laboratory there has grown. For an appreciable period the development of methods of analysis and tests continued to form the greater part of the labors of the laboratory. As a consequence the first volume of a collection of standard methods for use within the Group was published in 1920. Since then this collection has been steadily improved and extended, in consultation with the national and international standardization bodies. The central marketing organization of the Group decided to have an investigation made as to the behavior of gasolines in internal combustion engines then coming into their own. This work was entrusted to Sir Harry Ricardo. Begun in 1917, his labors led to the introduction of the "highest useful compression ratio" in a test engine of special construction as criterion for the anti-knock properties of gasolines.

Following the first world war the laboratory at Amsterdam began to grow rapidly. This period was particularly notable for the study of Venezuelan crude with its high asphalt content. The necessity of producing from it gasoline, diesel, lubricating, transformer and other oils to satisfy the inspection requirements then in force called for the solution of several refinery problems. In addition, the laboratory sought for new processing methods and new possibilities of applying existing ones. A pilot plant was erected for the study of refining of lubricating oil by treating it with liquid SO_2 as extracting agent, and the "cracking" of oils also received full attention. As to search for new possibilities of applying products two subjects were to the fore. First, the large quantities of bitumen that became available, when processing Venezuelan crude, led to a search for new possibilities of using it. These studies have yielded a rich harvest. There is, for example, the Shellperm process for making sand layers impermeable by water, the use of bitumen for the consolidation of sandclay mixtures and many other uses for road construction and hydraulic engineering purposes. Second, the reactivity of unsaturated compounds in cracked gases offered interesting possibilities for the production of chemicals. In Amsterdam attention was directed in the first instance to the synthesis of isopropyl alcohol or acetone from propene. In 1924 an investigation was started on behalf of the Group in Sir Harry Ricardo's laboratory on high speed diesel engines. It led to the development of a special form of combustion chamber, which offered the advantage of being less

fastidious with regard to its fuel than other constructions.

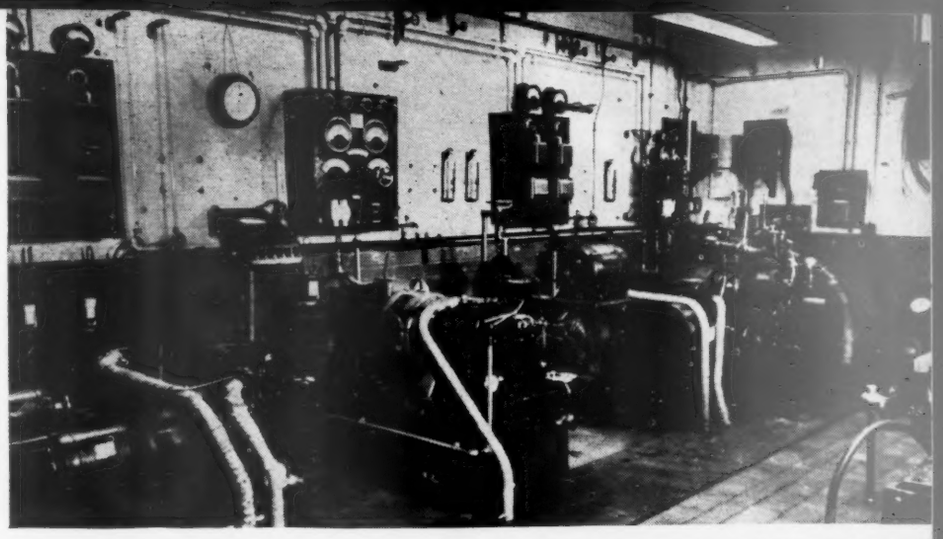
The year 1928 saw the birth of two new research institutions within the Group, first, the laboratory at Emeryville, near San Francisco, of the Shell Development Company, set up for the primary purpose of fostering a chemical industry from petroleum (and natural gas) derivatives, beginning with chemicals obtained from cracked gases; and second, the Engine Testing Station (now the Royal Dutch-Shell Laboratory) at Delft, founded for the purpose of throwing light on the factors determining the serviceability of diesel fuels.

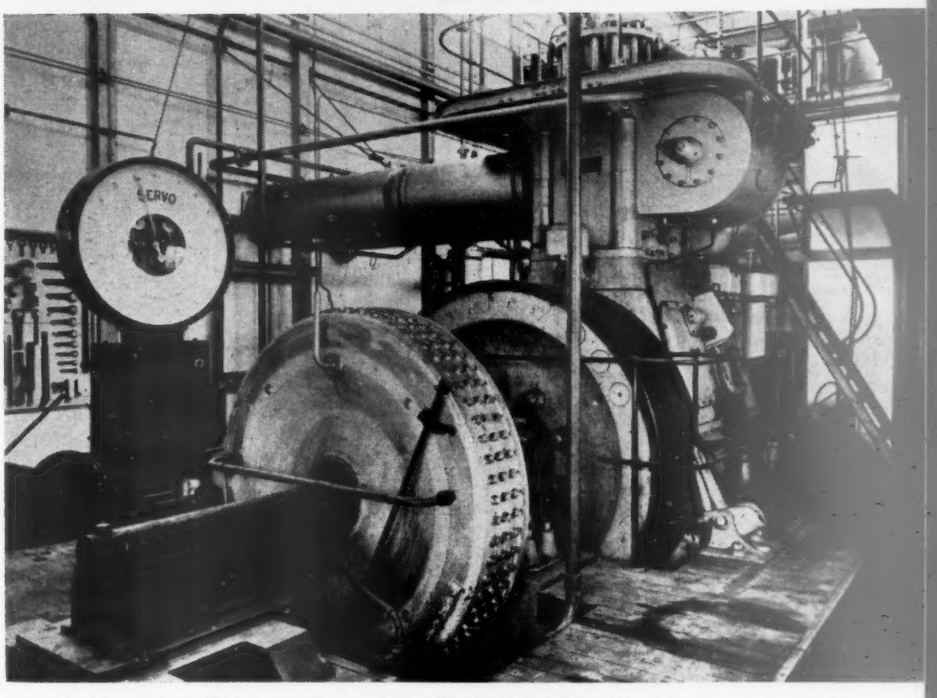
The Emeryville laboratory developed in rapid succession methods for making alcohols, ketones, esters, etc., beginning from propene and the butenes. Of particular value was the discovery of the possibility of chlorinating olefines at high temperatures by substitution. This opened up a vista of new possibilities of synthesis, including synthetic chlorohydrins, glycols and glycerine. Several of these processes have been applied on an industrial scale in the plants of the Shell Chemical Corporation in the United States and subsequently in the large complex of chemical plants erected close to the Group refinery at Stanlow in England. Apart from the synthesis of ammonia the entire chemical industry of the Group is based solely on processes developed in its laboratories.

Results of research in the chemical field that have ripened into commercial applications are briefly recapitulated.

The four pillars on which the Group chemical industry rests are the nitrogen fixation industry, manufacture of solvents and related compounds, production of synthetic detergents and wetting agents, and the preparation of polyvinyl chloride (PVC) plastic. In 1930 the Shell Point nitrogen fixation plant was built at Pittsburg, California. It uses the locally produced natural gas for the preparation of hydrogen and makes ammonia by combining it with atmospheric nitrogen. Much of the output is put on the market as ammonium sulfate, but ammonia is also supplied for direct application to the soil by so-called nitrogation and nitrojection processes, both developed by the Shell Chemical Corporation in California.

In the same year a small plant for the production of secondary butyl alcohol was put into operation on a semi-commercial scale at Martinez near San Francisco. In 1931 the manufacture of tertiary butyl alcohol and methyl ethyl ketone was added. Large plants for the production of these products were taken into service two years later. To these were added the manufacture of isopropyl alcohol and acetone in 1935.





Top photo, single-cylinder gasoline engines for testing lubricating oils for performance. Lower photo, one-cylinder marine engine at Delft, Holland laboratory, to test fuels, lubes.

Acetone is prepared from the isopropyl alcohol by withdrawing hydrogen, which is utilized for hydrogenation processes. The following year the Dominguez plant, also manufacturing butyl alcohols, isopropyl alcohol, and ketone, came into operation. Before the second world war broke out installations were added to these plants for the preparation of diacetone alcohol, mesityl oxide, methyl isobutyl ketone, and other products.

The large chemical works at Houston on the Gulf of Mexico was put into operation in 1941. Apart from the manufacturer of alcohols and ketones a plant was also built there for the production of butadiene. Two years later a large butadiene plant was built for the American Government at Torrance near Los Angeles. Erection and management were entrusted to the Shell Chemical Company. In 1945 a start was made at Houston with the production of allyl chloride, allyl alcohol, and D.D. In 1948 the first synthetic glycerine plant in the world came on stream at Houston, where another unit was opened for manufacture of ethyl alcohol on the basis of ethylene obtained from cracked gases.

While seeking, in the early part of the 'thirties, methods of preparing higher alcohols from unsaturated long-chain molecules, the idea was conceived in Amsterdam that synthetic wetting agents could be prepared from them. Thus a process was evolved for the manufacture of synthetic detergents from crude paraffin wax obtained as a byproduct of lubricating oil manufacture. After a small pilot plant for the production of these products had been installed in Amsterdam in 1935, the designing of a large-scale factory was begun in 1939. The Stanlow plant in England was put into operation early in 1943. In mid-1949 a second plant

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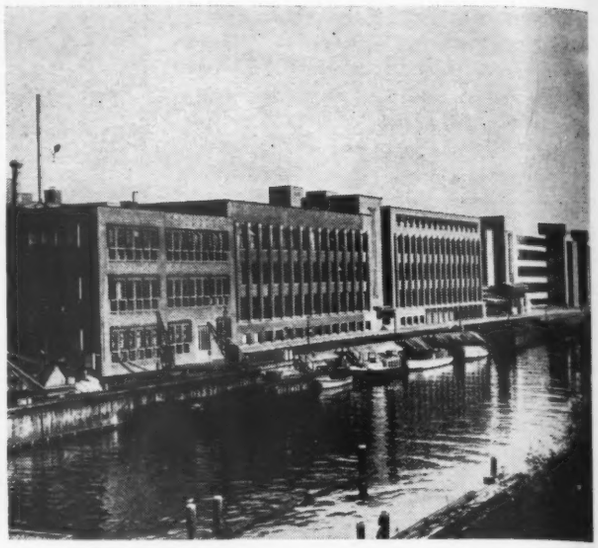
Shell Research Laboratories, Emeryville, California, U. S. A.



Royal Dutch-Shell laboratory, Amsterdam, Holland: The "Small" lab, the "Main" lab and the "New" laboratory.

was commissioned at Pernis near Rotterdam, while in the same year the construction of a similiar plant was begun at Petit-Couronne, in France, which is now operating to capacity.

Last, in the latter part of 1949 the first Group factory for the manufacture of polyvinyl chloride (P. V. C.) went on production at Rotterdam-Pernis. Expansion of the petroleum chemical industry during the past 25 years has been unprecedented in the world history of this enterprising field. And the Royal Dutch-Shell Group has fully shared in this unique expansion.

At Delft laboratory, diesel engines of representative makes driven under clearly defined conditions were set up, which enabled accurate observations and, as far as possible, measurements to be carried out. Apparatus was designed and developed for recording the pressure curve in the combustion chamber, for observing and photographing the combustion process, etc., of the engine under study. The results obtained gave a deeper insight into the complex influences of fuel, lubricating oil, operating conditions and construction on the behavior of the engine. As criterion for the ignition quality Delft put forward a concept that has been adopted and is being used as the cetane number the world over. Investigations were extended step by step to include gasoline engines, especially aeroplane engines, the problems of lubrication in the widest sense, and burners for the most varied applications.

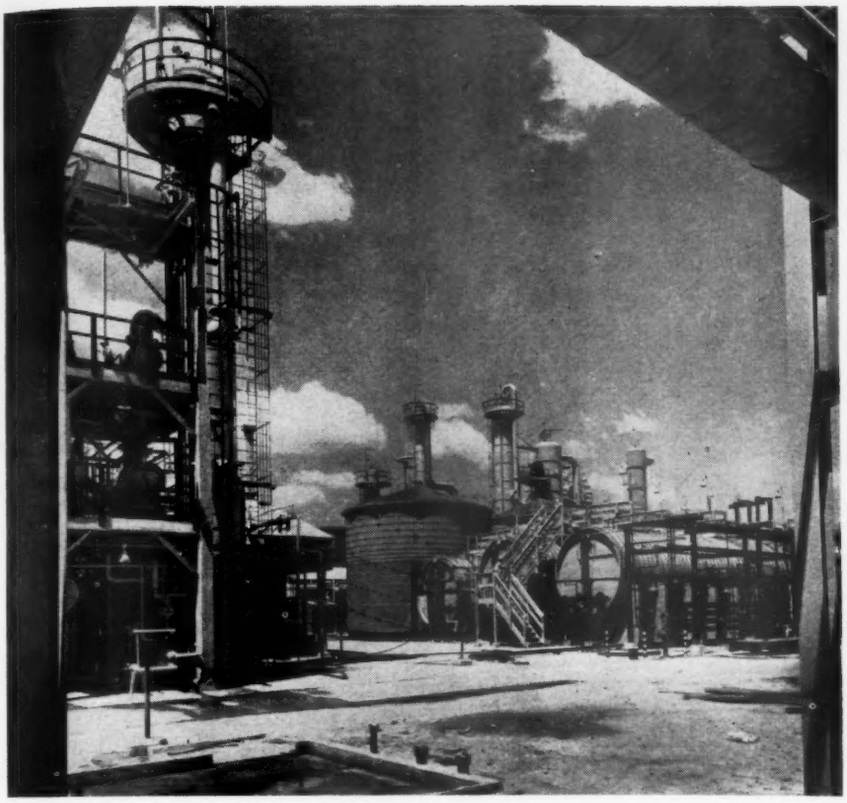
Since 1933 the work of the Emeryville laboratory has been extended to problems of oil technology, and in 1939 the program included investigations in the sphere of petroleum production, refining, uses of oil products, and the manufacture of petroleum chemicals. Although in Emeryville stress was laid on chemical synthesis and in Amsterdam more on oil technology proper, the technical development of petroleum processing continually showed a more and more pronounced chemical tendency. In the years 1928-1939 the laboratories at Amsterdam and Emeryville grew into institutions ranking among the largest of their kind in the world.

In the search for better petroleum products it was found that important results could be attained by very small additions of certain substances termed "additives." Not only did the discovery of effective additives for bitumens, gasolines, lubricating oils, and other products offer a wide field of research, but there was further scope in the elaboration of methods for their manufacture. Again, when improving the anti-knock value by adding anti-knock agents to gasolines as they can be produced by combined application of fractionation and cracking from crude oil, a sort of natural limit is reached. To get beyond this limit means had to be found of producing artificially those gasoline components that had in themselves a high anti-knock value. The Group laboratories have done pioneer work in discovering and/or developing the polymerization, alkylation, isomerization, hydrogenation, and dehydrogenation processes that render this possible.

Although the Amsterdam laboratory, which had by far the largest number of personnel, did much to solve the direct processing problems of the Group refineries in East Asia, the Middle East, and Europe, the corresponding function with reference to its installations in the United States was executed by laboratories at Martinez, Wood River, Wilmington, and Houston. All these American establishments had been separated from the normal refinery control work. And between them a functional division of labor had grown up in this fashion. Of the laboratories situated west of the Rocky Mountains, i.e., at Martinez and Wilmington, the former specialized in the development of products and the latter in the development of processes. Similarly, as regards the Eastern part of the United States, Wood River worked mainly on products, and Houston on processes. The Houston and Wilmington laboratories were equipped with semi-technical installations, and those at Wood River and Martinez with all the equipment required for the analysis and testing of petroleum products including fully equipped engine test benches.

During the second world war the energies of the Group were directed to meeting the requirements imposed by the Allied war effort. The Amsterdam and Delft laboratories were eliminated as active departments, and many discoveries made by Amsterdam and Emeryville in the years before 1940 had to be elaborated in the shortest possible time for industrial application on an enormous scale. Great extensions were therefore made to the American laboratories, and the staff of Shell Development Company was doubled between 1940 and 1945. In 1948 this company received the "Chemical Engineering Award."

In England, a laboratory for the testing and development of fuels and lubricants for aeroplane engines was opened by the Group at Thornton in Cheshire in 1941. It was rapidly extended and was made use of by the British Government as official institution for fuel and lubricant research. In addition, a chemical research laboratory was set up at Thornton, where investigations were made on additives for lubricants, petroleum-base plasticizers for synthetic rubbers and other



These 60-ft long wooden tanks are mixing vessels in Shell's glycerin-synthesizing plant at Houston, a process that is the result of extended Shell research.

plastics, synthetic lacquers, and detergents and other chemical derivatives.

Immediately after the cessation of hostilities in Europe rehabilitation of the research institutions of the Group in Amsterdam and Delft were taken in hand and completed on time. A certain reorganization of the scope of operation assigned to Delft took place in the direction of more mechanical research work. At the same time the need was felt for a considerable extension of research activity, both with regard to exploration and production of crude oil and to the use of petroleum products for agricultural and horticultural purposes. In 1946 an agricultural research station with extensive experimental facilities was put into service by the Shell Oil Company at Modesto in California, where experiments were made into the use of petroleum and other products as weed killers, insect controls, and kindred farming aids. The Amsterdam laboratory has been active in this field for many years, and in the United Kingdom a model farm is functioning at Woodstock, Kent.

In 1947 the Shell Oil Company launched its new Exploration and Production Research Laboratory at Houston, which is wedded to the study of the various problems connected with the search for and winning of oil and their inter-relations. It acts as the Group center of research activity in this specialized sector, in which Emeryville laboratory is no longer employed and Amsterdam only to a limited extent. At Thornton the existing laboratories have been further enlarged to include sections for the testing of diesel engines and combustion turbines. These various divisions have been united to form one large research complex, officially opened in 1948 as the Thornton Research Center. Its main object is to carry out purely scientific as well as applied studies to develop the application of the Group products in the widest sense, taking into account the needs of its markets outside North America. Demands made by the latter market are studied in the laboratories at Wood River and Martinez as far as petroleum products are concerned. For the fulfillment of the corresponding task with reference to petroleum chemicals Shell Chemical Corporation has had a laboratory of its own in operation for some years at Martinez.

The following are some of the examples of what has been achieved by the Group during the past decade: Perfection of a process for making cumene (isopropyl benzene) which was immediately made available to the Allied Forces and the oil industry at large. The "Turbogrid" distillation tray, which ensures more intimate contact between liquid and vapor in refinery distillation columns, thus leading to a considerable saving in the cost of equipment and to an increase of processing capacity. The development in the United States of a process for the manufacture of glycerine from petroleum. The successful application of petroleum-based chemicals in combating such major pests as the mosquito, the locust and the tsetse fly. The new chemicals aldrin and dieldrin, in which Shell owns the exclusive manufacturing rights, are playing an important part in this context. The air-solutizer sweetening process developed for improving the quality of motor gasolines and aviation turbine fuels by reducing their sulfur content. The "Shell trickle hydrosulfurization process" for removal of sulfur from middle distillates. By this process high-quality diesel fuel and gas oils can be produced from crude oils with a high sulfur content. A new type of asphalt runway resistant to the disintegrating effect of the blast from jet engines. Also the Group cooperated with Sir Frank Whittle in the evolution of the gas turbine, and work subsequently carried out in this field by the research and development department of Shell Tankers Ltd. led to the first use of gas turbine propulsion in merchant vessels, in the Shell tanker *Auris*.

> Petroleum companies produced and delivered a record of 136,532,246 gal of gasoline per day during 1952. This would be enough gasoline to drive an automobile for more than 376,122 years!

The scale on which industrial research can be fruitfully carried on rests, among other things, on the pace at which purely scientific research extends the frontiers of knowledge of the laws of nature, as well as on the availability of research workers of a sufficiently high calibre. By means of gifts to university laboratories in the Netherlands and in the United Kingdom and by establishing prizes and scholarships in those countries and in the United States the companies belonging to the Group are making a valuable contribution toward the healthy extension of academic research.

The applied and purely scientific work of the Group laboratories in the past has left its imprint in thousands of patents and in large numbers of publications in scientific and technical periodicals as well as in book form. It has shaped new technical processes and apparatus. Moreover, while engaged in this work the Group scientists have gained invaluable experience in the technique of industrial research. This warrants the legitimate expectation that in the future, as in the past, they will succeed in ensuring the necessary technical progress of the Royal Dutch-Shell Group. * * *

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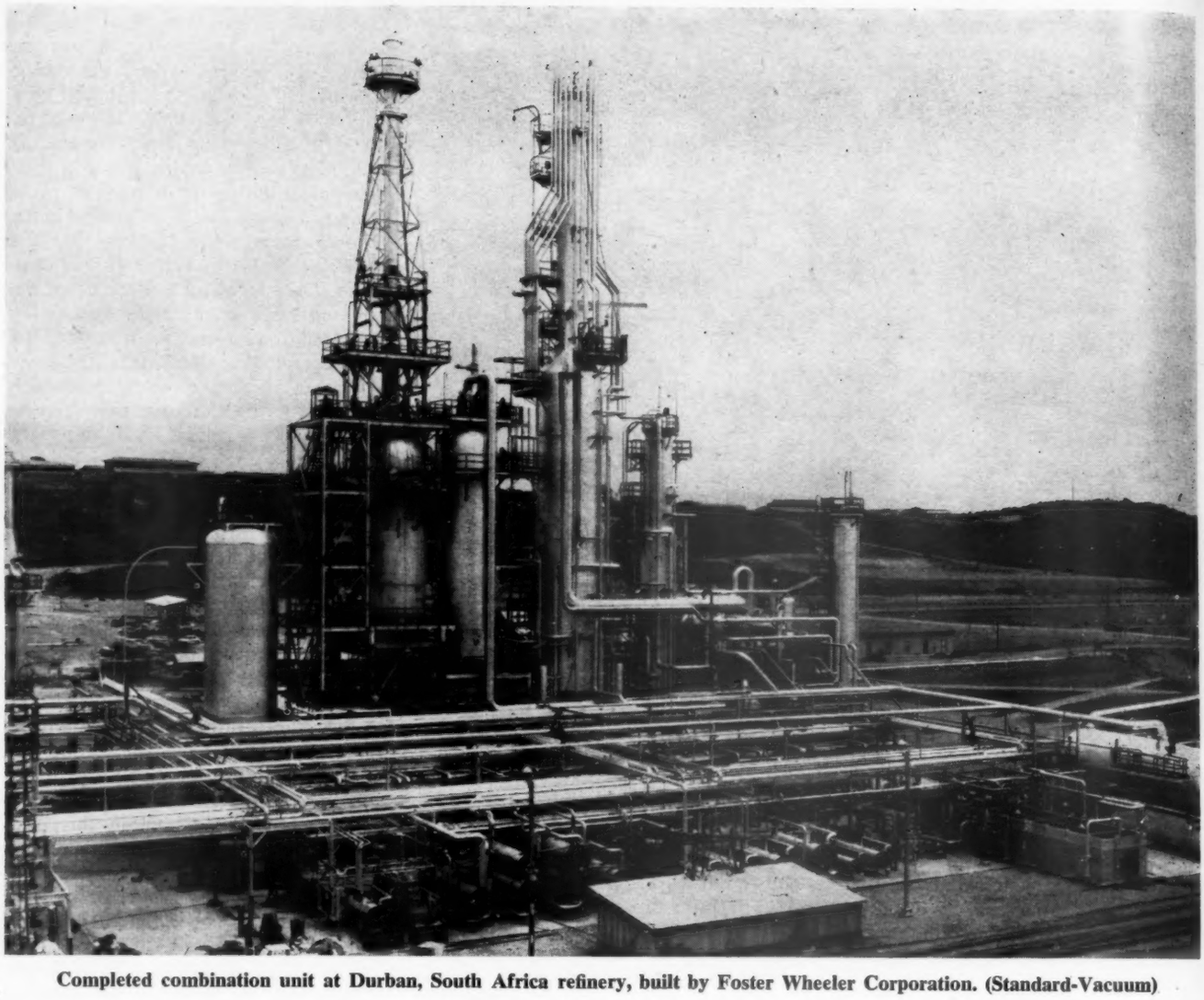


Completed combination unit at Durban, South Africa refinery, built by Foster Wheeler Corporation. (Standard-Vacuum)

New Refineries for South Africa and India

40,000 bbl per day combined crude-charging capacity will supply part of greatly increased local demand in these countries

H. M. DAVIDSON*

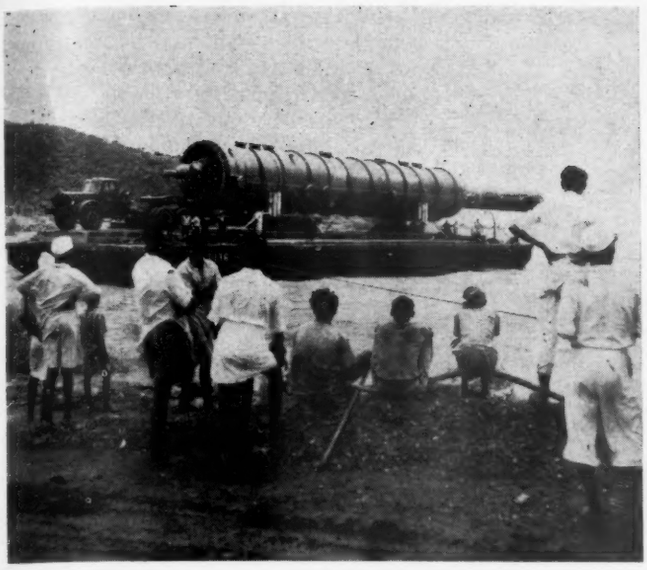
TWO major additions to the oil refining capacity of the Eastern Hemisphere — part of an expansion program that will increase Standard-Vacuum Oil Company's crude throughput rate from its 1953 level of 82,000 bbl a day to 150,000 bbl by 1955 — go into production this year at Durban, South Africa, and Bombay, India.

Both are fuel products plants with a combined crude-charging rate of more than 40,000 bbl a day. A third important addition to Stanvac's East-of-Suez manufacturing capacity, scheduled for completion in 1955, will expand the 2,000 bbl-a-day lube oil and asphalt plant at Altona, near Melbourne, Australia, into a 22,000-bbl fuel products refinery. In addition substantial changes looking toward greater throughput are being made at the Wakayama and Shimizu refineries of Toa Nenryo Kogyo Company, Ltd., a Japanese oil refining company in which Standard-Vacuum acquired an interest after the war.

Located in countries which have been obliged to import nearly all of their finished petroleum products, the

*Refining Coordinator, Standard-Vacuum Oil Company.

EXCLUSIVE



Main fractionator coming in by barge across Bombay harbor, to Trombay Island site, India. (Standard-Vacuum)

Laying drains at Trombay Island refinery, India, during monsoon (rainy) season. (Standard-Vacuum)

new Durban and Bombay refineries are destined to make important changes in the oil distribution patterns of South Africa and South Asia.

Oil consumption in both areas has risen sharply since the war — 180 per cent in the Union of South Africa and 140 per cent in India. The new refineries will make both countries less dependent upon imported products. Substantial savings in currency exchange also will result.

Standard-Vacuum's interest in building a refinery in South Africa dates back to early 1948 when an engineering survey party investigated several possible sites. Following discussions with government representatives, it was announced in February, 1951 that arrangements had been concluded for the Durban project.

The 15,600-bbl Durban refinery is being constructed on a 285-acre site near Durban Harbor where terminal facilities provide convenient access to both inland and coastal markets. The $25,000,000 refinery will be operated by a Stanvac subsidiary, Standard-Vacuum Refinery Company of South Africa (Pty), Ltd.

The agreement with the Indian Government for the refinery at Bombay was signed in November, 1951 and construction was started late in December, 1952.

The Bombay installation will be a 25,000-bbl plant situated on Trombay Island in Bombay Harbor. Representing an expenditure of $35,000,000, it will be the first major multi-products oil refinery for India. Incidentally, it represents the largest American private capital investment in that country since it became a republic. It will be owned and operated by Standard-Vacuum Refining Company of India, Ltd., in which private Indian capital will have a 25 per cent preference share interest.

Both the Durban plant, now on stream, with dedication planned for May, and the Bombay refinery, scheduled for start-up later in the year, will incorporate the latest design of "combination unit" operations, employing a maximum of process integration. The basic processes included in the two plants are crude distillation, thermal reforming, model IV fluid catalytic cracking, sulphur dioxide extraction and combined sweetening.

Instead of separate processing steps the "combination units" embrace all three processes of distillation, catalytic cracking and reforming. This means fewer tanks, less steel and shorter pipelines, resulting in a saving also in the cost of offsite equipment. Centrally controlled operation is possible as well.

The crude oil flows first to the crude pipe still where four "cuts" are taken: Light naphtha overhead, heavy naphtha or kerosine distillate, gas oil and bottoms. The light naphtha is stabilized and sent to doctor sweetening. Part of the heavy naphtha goes to finishing operations for the production of power kerosine but the bulk of this cut serves as feed for the thermal reforming furnace.

The Saudi Arabian Government plans to construct an ammonium sulfate and dry ice plant which will utilize natural gas from oil fields of the Arabian American Oil Company. This would be the first important commercial use of natural gas in the Middle East. The producing companies in that area now use gas within their own organizations for utilities, to drive pumps and for field use, leaving large excess quantities which must be flared.

The products from the reformer furnace are fractionated, the major product being high-octane thermal reformed gasoline which is stabilized and then doctor treated. When a kerosine distillate is made, it is processed through the SO_2 extraction plant for the production of illuminating kerosine. The third cut from the pipe still, the gas oil, serves primarily for the production of automotive diesel oils, although some of this stream is used as fluxing stock for fuel oils. Some also may be used as feed for the catalytic cracker. The bottoms, containing all the heavy fractions of the crude, is fractionated to obtain catalytic cracking feed and a heavy bottoms used either as feed to the asphalt plant in Durban or as a heavy fuel component in Bombay.

The central feature of the processing equipment in each of the new refineries at Durban and Bombay is the model IV catalytic cracking unit that is smaller in size, easier to operate and lower in cost than its predecessors. These improvements make it ideally suited for overseas refining operations. Fresh feed for the catalytic cracker's reactor is obtained from several sources, the most important being the bottoms from the crude pipe still. The catalytically cracked products are fractionated into gasoline, distillate and fuel oil components as well as feed for recycling.

The remaining processes in the refinery are essentially standard. All the gasoline components, after being stabilized, undergo doctor sweetening before the addition of tetraethyl lead, dye and inhibitor after which it is ready for marketing as motor gasoline.

The SO_2 extraction unit in each plant contains complete facilities for treating the illuminating kerosine cut

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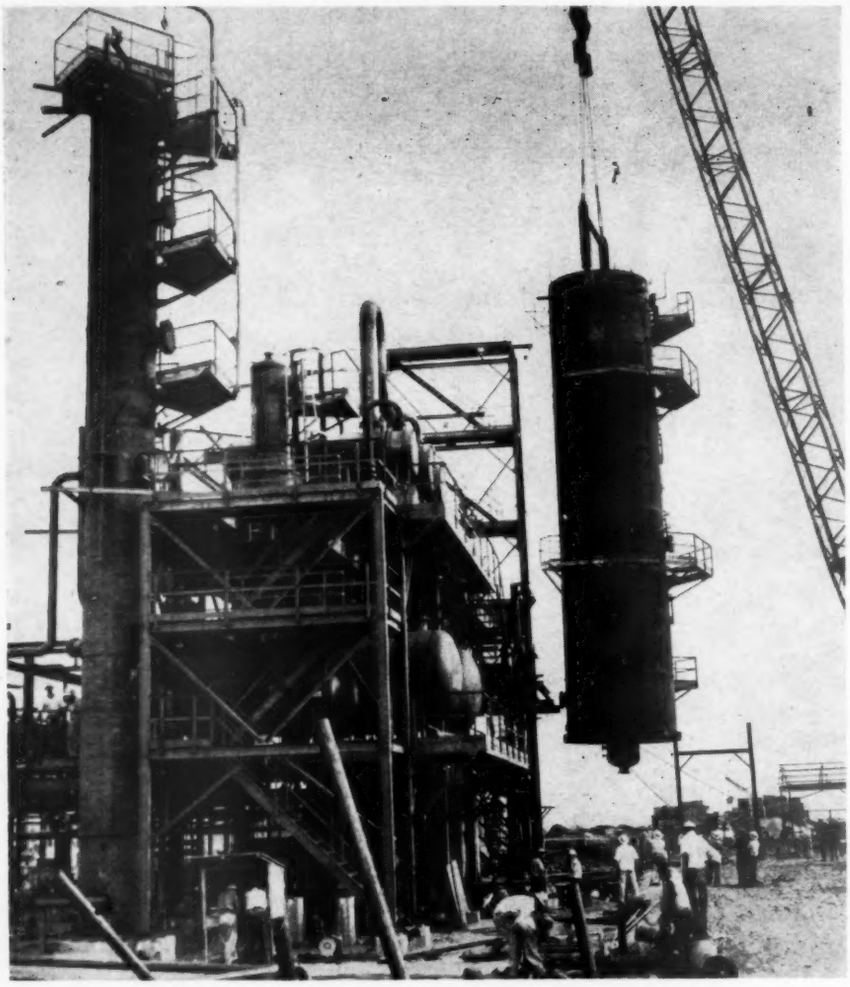

Lower half of fractionator tower is being set in place in a combination distillation fluid cat cracking, reforming unit at Durban, South Africa.

PHOTOS COURTESY STANDARD-VACUUM.

Steel riggers setting framework in 25,000 bbl refinery at Bombay, India.

which then is finished by caustic washing, doctor sweetening and filtration. The quality of power kerosine is controlled by doctor sweetening and sand filtration. The asphalt unit is designed to produce either cutback asphalt or oxidized asphalt. The light cycle gas oil from the catalytic cracker is sent through a caustic wash and is blended into diesel oils and heavy fuel oils.

Auxiliary equipment at Durban includes the asphalt plant, mentioned earlier, a grease plant and manufacturing facilities for the production of 5-gal tins. In addition field work has started on the installation of a non-selective polymerization plant.

Based on a crude charging rate of 15,600 bbl per day of Persian Gulf crude, a typical yield in barrels per day for the Durban refinery will be motor gasoline, 5800; power kerosine, 1500; lighting kerosine, 800; automotive diesel, 900; industrial diesel, 800; marine diesel, 100; fuel oil, 3700; asphalt, 400; refinery fuel and loss, 1600.

In terms of petroleum demand in the Union of South Africa, the Durban refinery will be able to supply approximately one-fifth or 180,000,000 Imperial gallons a year of the oil products currently consumed in that country.

When fully on stream later this year, the Bombay plant will turn out 300,000,000 Imperial gallons of petroleum products annually. Nearly one-third of this output—90,000,000 gal—will be motor gasoline that will be sufficient to keep every car, bus, and truck in India going for four months. The 40,000,000 gal of illuminating kerosine that the refinery will be able to produce will be sufficient to supply light for all of India for two months. The annual yield of other products will be 59,000,000 gal of diesel oils, 58,000,000 gal of industrial fuel oil and 49,000,000 gal of bunker fuels.

What do these Stanvac investments mean in terms of direct and indirect benefits to the Indian and South African economies, apart from the increased tax revenues and savings in foreign exchange? New employment has been created during the construction periods, and some members of these construction crews will remain as year-round employees to operate and maintain the plants. Others are being trained in accordance with the company's policy of training nationals to the maximum possible extent.

Materials and operating supplies wherever possible are purchased within the countries where the refineries are located. Experience has shown in other parts of the world that additional industries develop near oil refineries to utilize the by-products of petroleum refining, and this is a good possibility at Bombay and Durban. ★ ★ ★

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TECHNICAL FORUM

Dealkalization by Chloride Exchange

Q In a descriptive article covering the Ambrose gasoline plant in the December, 1953, issue of The Petroleum Engineer, Refining and Petrochemical Edition, by M. F. Wirges, on page C-21, the following statement appears:

Feed water for the boiler system is treated by ion resins in two vessels. The first vessel removes the hardness and the second removes bicarbonate, sulfate and nitrate ions. Brine solution is utilized to regenerate the softener and the dealkalinizer.

Will you give me more information on the process of removing bicarbonate, sulfate and nitrate ions as mentioned above or suggest an organization that has such information available.

K. C.

A One of the more important disadvantages of sodium zeolite softening of boiler feed water is that there is no reduction in alkalinity as the hardness is removed. However, the low hardness of its effluent water and the simplicity of equipment and operating knowhow required make its use in many installations desirable.

When used with waters containing a relatively high alkalinity, concentration of the alkalinity within the boiler may cause carryover of solids in the steam. The decomposition of carbonate and bicarbonate within the boiler will release carbon dioxide and thereby result in corrosion of return condensate and steam lines. Blowdown requirements to maintain the alkalinity content of the boiler water at an acceptable level may not be economical.

A comparatively recent development for the removal or reduction of alkalinity in boiler makeup water is the use of highly basic resins operating on the chloride cycle. In this system the chloride ion is substituted for anions in much the same manner as sodium ions are exchanged for cations in the ordinary sodium zeolite softener.

One of the principal advantages of sodium zeolite softening, simplicity, is also realized in the chloride exchange system of dealkalization. The use of sodium chloride in the regeneration of both units simplifies the storage facilities for the regenerant chemicals. Likewise, the appearance and operation of the two units is almost identical. Operators trained to operate the cation unit can easily be trained to operate the anion unit satisfactorily. Freedom from the use of acid is a decided advantage in many installation.

Unlike the demineralization method, wherein almost distilled water is obtained, the solids are not removed but converted to sodium chloride. Like other means of treating boiler water, the method is not always the best available. As sulfates and nitrates are also removed, water containing a high concentration of these ions result in high regenerating costs. As there are no advantages in removing these ions, the dealkalization of such water by chloride exchange should be compared with other methods available.

A second disadvantage of the system is that complete dealkalization is not obtained. Alkalinity content of the effluent water will range from 5 to 10 ppm, or 5-10 per cent of the influent alkalinity, whichever is greater. These values vary according to the manufacturer.

Most manufacturers specify the use of sodium hydroxide in the regenerating brine. It is reported that an improvement of 50 per cent in the exchange capacities of the resins are obtained by this combined treatment. The use of sodium hydroxide creates an additional handling and storage problem.

Guy Duren.

References

Applebaum, S. B., Paper Presented at 13th Annual Water Conference, Pittsburgh, Pennsylvania, October 20, 1952.

Maher, E., Industry and Power, 102-103, September, 1952.

Isophthalic Plant Set

Standard Oil Company of California has reported plans for construction of a multi-million dollar plant at its Richmond, California, plant to produce isophthalic, a chemical intermediate.

New plans will have capacity of 50,000,000 lb of isophthalic, which till now has produced only in the laboratory.

The company has reported that isophthalic as a rew material for plastics industry, and for manufacture of surface coatings.

Completion is scheduled for mid-1955.

Autoignition Temperature of Diethylene Glycol

Q We refer to The Petroleum Engineer's Continuous Tables (Installment No. 96), Sheet 3, P 600.11, Page 213, June, 1945.

The autoignition temperature for diethylene glycol is shown at 444 F, but since this value is so considerably lower than that for ethylene glycol, we are prompted to inquire whether the data listed may have been a mis-print.

Information in this connection will be much appreciated by us.

S. P.

A This is in answer to your letter of October 27, in which you inquired about the auto-ignition temperatures of ethylene and diethylene glycols.

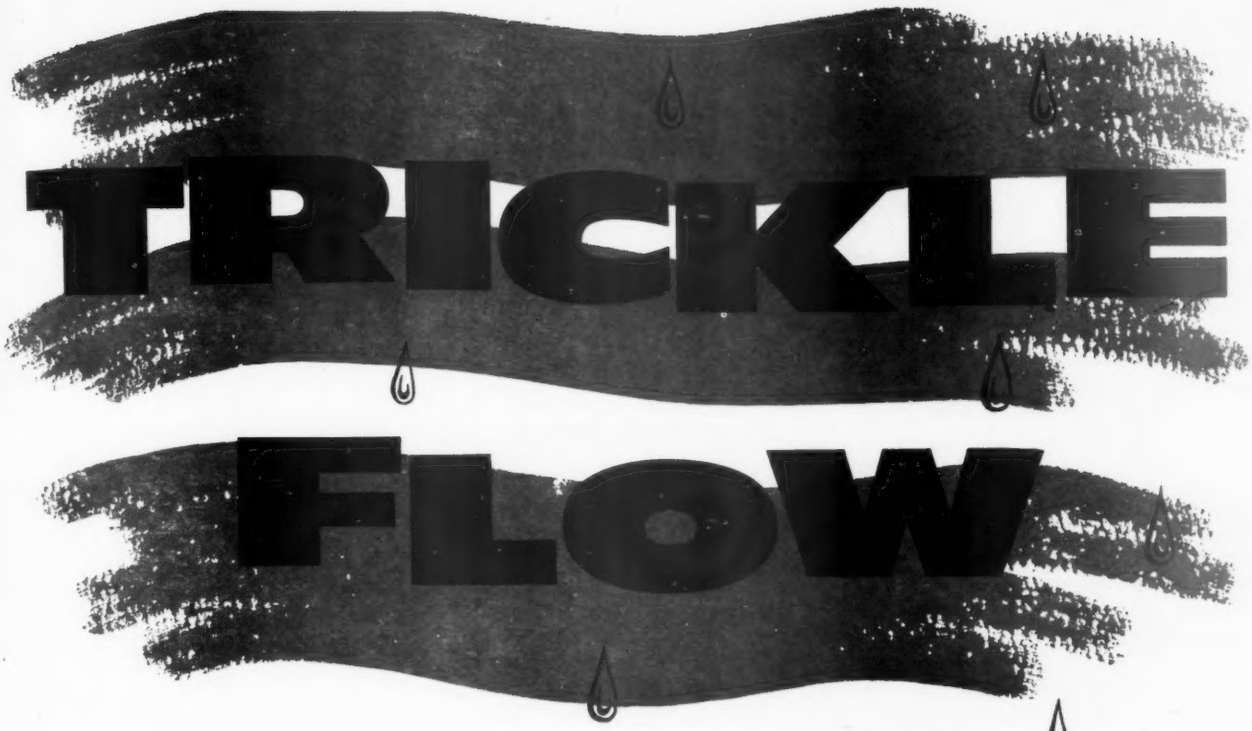
Our laboratories have run these data using the ASTM method which requires that the glycol be heated in a bath of molten lead. The results obtained by our laboratories on the auto-ignition point of ethylene glycol are quite close to the figure which you mentioned in your letter. The figure which you listed for ethylene glycol was 775 F and our laboratories have obtained a figure of 779 F. In this type it is our opinion that the four degree difference between the values is well within the limits of experimental error.

You mentioned a figure of 444 F as the reported auto-ignition temperature for diethylene glycol and the values obtained in our laboratories by the ASTM method are appreciably different from this value. On the determinations our laboratory has made they have obtained values ranging between 663.8 F and 683.6 F. We have checked the recent ACS monograph entitled, "Glycols" which was written by George O. Curme, Jr., and Franklin Johnston, and the value they give for this property is 663 F and it is our feeling that since this figure compares quite closely with the 663.8 figure obtained in our laboratory that this value is probably correct.

J. P. H.

☆ ☆ ☆

For the thirty-second consecutive year, a new high was set in sales of liquefied petroleum gas. The 1953 sales soared about 10 per cent over 1952 records, to bring the total to an estimated 4,920,000,000 gallons.



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NPA Discusses Phosphorus Additives

Taxes, labor, excess capacity, and the economy are reviewed at meeting of refiners in Cleveland

EUGENE B. BRIEN*

HIGHLIGHTS of the 51st semi-annual meeting of the National Petroleum Association, oldest association of oil men in the world, held in Cleveland, Ohio, were discussions of refining activities for the year, amendments to the Taft-Hartley Act, the national economy, and gasoline additives.

A. W. Scott, president of NPA and Wolf's Head Oil Refining Company, warned against unhealthy forms of competition, as seen in the current false emphasis on octane ratings, arising out of the existence of excess refining capacity. The trend to lighter fractions in making lubricating oils, the rising demand for the middle fractions by the rapid dieselization of the railroads, and the great increase in jet fuels, are, he said, the greatest problems refiners will face in 1954. He demanded that the industry be relieved of the lube oil tax, which frequently adds more than 50 per cent to its wholesale price.

Additives Symposium

Two opposing camps lined-up to thresh out the subject of gasoline additives and preignition. Advocates of Shell's tricresyl phosphate, led by R. E. Jeffrey, L. W. Griffith, and E. Dunning, reiterated their claims that TCP eliminates spark-plug fouling and preignition (deposit-induced ignition), both very prevalent problems.

Using a typical cross section of cars in one survey, they found the spark plugs of 50 out of 71 cars missing fire. When TCP was added to a base fuel, they said, road tests showed a 70-150 per cent increase in spark-plug mileage.

Shell speakers declared that combustion chamber deposits are markedly more resistant to burning in the presence of phosphorus and are therefore less likely to cause preignition. Phosphorus in fuel also lowers the octane requirement by an average of two numbers, they stated.

Controlled road tests in city driving showed abnormal combustion noises from preignition in full-throat accelerations. Abnormal noises were encountered in 75 per cent of the accelerations in cars using a base fuel; this was reduced to 35 per cent of accelerations with TCP treated fuel.

In like manner, they said that out of 20 cars, 14 showed signs of preignition; after running 1500 miles with TCP fuel, 10 cars were back to normal and the reduction in octane requirements averaged about two numbers with fuel containing additives.

Esso Laboratories

Shell's opposition came from C. L. Fleming, Esso Laboratories, Standard Oil Development Company. Less than 7 per cent of cars now on the road have preignition problems that might be helped with TCP, Fleming and his three co-authors reported. Studies by Sun Oil and CRC are in substantial agreement, they pointed out. Of 512 late model cars tested, less than 10 per cent were preignition limited. Furthermore, as many of these cars have preignition needs below the octane levels of current quality fuels, most of these cars (98-99 per cent) can readily be satisfied by gasoline now generally available. The problem needing most attention at present, according to their surveys, is the lessening of detonation, not preignition.

Spark-plug fouling is not a serious problem, Fleming continued. In one study, only 3 per cent of 66 late model cars driven half a million miles showed spark-plug difficulties.

Esso held that the proper approach to preignition and detonation problems is the reduction of combustion chamber deposits, which can be controlled considerably by using the proper lubricant. A study demonstrated that preignition requirements exceeded detonation requirements in 17 per cent of observations compared to 40 per cent with conventional lubricants.

Particularly with respect to preignition tendencies, Esso said, the use of gasoline with the 90 per cent point in the range of 300-320 F instead of 340-360 F subsequently reduces harmful deposits formed from the fuel.

Phosphorus Additives

Esso Laboratories' studies show, reported Fleming, that tricresyl phosphate is effective in repressing wild ping preignition, but it also has several deleterious side effects. A phosphorus additive (0.2 T. TCP) increased deposits by 20-30 per cent, thereby increasing detonation requirements, both in clean and older combustion chambers, and in very high compression engines. In clean engines the use of phosphorus additives increased detonation requirements by 0.5-0.1 octane number in both field and laboratory tests. Although Fleming admitted the additive does reduce wild ping of preignition noises, he held that its use demands an increase in car octane requirements.

In controlled field tests, four automobiles with "dirty" engines had a detonation requirement of 93 octanes, up from 90 before the use of the additive. Some reduction in preignition was noted, but it was not entirely eliminated, he continued.

Esso's tests in high compression cars (9.5-10:1) gave substantially similar results: Octane requirement was increased by the use of tricresyl phosphate. Twenty-eight hundred miles after equilibrium, preignition requirements had not changed significantly, but detonation requirements had jumped three octane numbers from 95 to 98 in the 10:1 engine.

The authors concluded that they have found no evidence to show a clear cut advantage for tricresyl phosphate in low to moderate concentrations in reducing octane requirements, but that much evidence was found to show that its use increases octane requirements.

H. J. Gibson and H. E. Hesselberg, Ethyl Corporation, presenting a third paper on "The Preignition Problem," said that practical control of preigni-

*Eastern editor.

EXCLUSIVE

tion noise can be eliminated by raising the octane number. Fuel and oil technology can also make significant contributions to the control of preignition, they stressed, as well as engine design, such as the change from ell-head to valve-in-head design.

Solution of the preignition problem may lie in the use of proper lubricating oils and in the use of fuels that burn completely, they agreed. Hence, the more volatile the fuel, the less it will contribute to preignition. By cutting fuel end-points from 450 to 360 F, they got significant reduction in preignition.

Additives can be helpful in handling the problem, Gibson admitted. Ethyl's additive and other phosphorus compounds can control preignition completely in sufficient concentration, but the effect of additives on the frequency with which preignition occurs cannot be easily evaluated. When degradation of antiknock quality due to phosphorus occurs, he continued, its magnitude depends on many variables other than the additive.

The authors concluded that preignition is a real problem in some makes of cars and will become a greater problem as octane rating goes up. Although not the only route, one means of approach is the additives route.

Formal Comment

Prepared comments were presented by three other companies. The Texas Company's W. E. Kuhn said he did not believe phosphorus additives were much help because preignition exists only in a small number of cars and spark-plug fouling is not a real problem.

The Atlantic Refining Company, represented by J. C. Geniesse, held that TCP markedly improves inaudible preignition, but that the use of the proper lube oil could increase octane by 3-4 points.

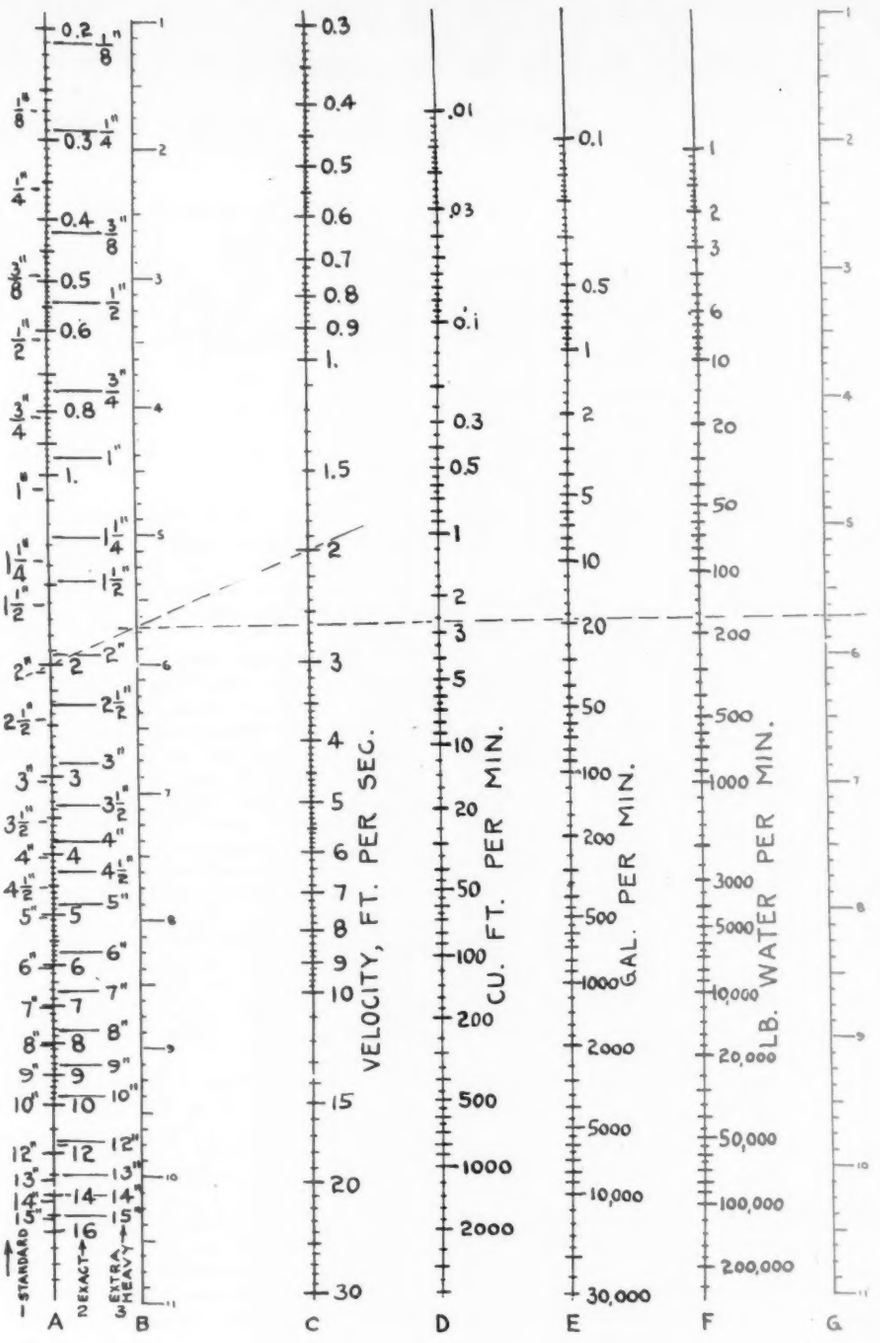
Sun Oil Company's J. G. Moxey ended the discussion by stating that Sun's research indicated the phosphorus approach was probably an unsound approach and that further research might better be concentrated on improving lube oils and gasolines. * *

PLANT AID

"All Purpose" Pipe Chart

We often want to know certain things about pipe, and we want to know quickly. We may want to know the cubic feet of liquid or gas flowing through the pipe per minute, the gallons per minute, the pounds of water per minute, the velocity of flow, or the exact internal diameter of the pipe regardless of its standard.

Here is a chart that takes care of most of these matters in a decidedly simple way. To apply the chart to a problem: How much water is passing through the pipe having an internal diameter of exactly 2 in., the velocity of the water being 2 ft per second.



Locate the 2 in column A over the word "exact" and from its point of intersection run a straight line through the 2 ft per second in Column G as shown by the slanted dotted line. This straight line intersects Column B. From the point of intersection in Column B run a straight line over the identical point in Column G, also as shown by the dotted line. The intersection of this perfectly horizontal line from Column B to Column G gives answers simultaneously in the three Columns D, E, and G. It shows that according to Column D, 2.6 cu ft per minute as flowing through the pipe. Column E shows that the volume of flow amounts to 19.5 gal per minute. And Column F tells us that if it is water the weight of that water is about 165 lb per minute.

Inversely, if any quantity in Columns D, E, and F is shown and it is desired to determine the velocity per second of flow through the pipe, this same chart can be used with equal ease. First run a horizontal line through the known point in D, E, or F and then through the located point in Column B run a straight line from the known pipe diameter and the intersection with Column C immediately gives the velocity of the liquid in feet per second.—WFS.

Rapid Lamp Method for Determination of Sulfur in Heavy Petroleum Distillates Featuring a Novel and More Efficient Absorber

WILLIS R. BATTLES*

A RAPID lamp method for the determination of sulfur in gasoline has been published.[1] This method utilizes the reaction of SO_2 plus iodine to form $2HI + H_2SO_4$ (Equation 1) and titration of the acid formed. For a description of the method and the micro lamp used, see Reference 1. A logical expansion of this method would be its use for sulfur determination in stove oils and heavier petroleum distillates. This paper describes the development and use of this method.

Development of Method

Absorber. A more efficient and more easily manipulated absorber was first developed and tested on gasolines of known sulfur content.

The chimney of this absorber (Fig. 1) was made from a 4¼-in. length of 25 mm pyrex tubing that was sealed to a 10-in. length of 1 mm pyrex capillary tubing. The capillary was then bent twice at 90 deg at 7½ in. and 9½ in. from the end of the tubing to the shape shown in Fig. 1. This capillary was then fitted to a No. 6 rubber stopper containing a short 6-mm glass tubing leading to a vacuum connection. The rubber stopper fits tightly into the top of a 100 ml graduate (with top 1 in. removed.). The capillary tubing (from chimney) was adjusted so that its lower end was about ½ in. from the bottom of the graduate. The absorbent solution used was the same as described before[1] [About 15 gm of pure ice plus 15 ml distilled water, 20 drops (about .4 ml) of .1N I_2 in methanol, plus 4 drops of starch indicator]. This absorber was much quicker to set up and transfer between consecutive lamp burnings. It also eliminated most of the error due to SO_2 absorbing on a moist surface [and becoming oxidized by oxygen of the air (Equation 2)] before contacting the iodine solution to react to form H_2SO_4 plus HI according to Equation 1.

(1) $SO_2 + 2H_2O + I_2 = H_2SO_4 + 2HI$ (4H formed per SO_2)

(2) $SO_2 + H_2O + \frac{1}{2}O_2 = 2H_2SO_4$ (2H formed per SO_2)

Table 1 shows the higher and more nearly theoretical results obtained with this new absorber as compared with the results obtained with the modified Ethyl lamp absorber described in Reference 1.

Burning mixes and lamp development. Burning undiluted stove oil or heavier distillates in the gasoline micro lamp[1] proved unsatisfactory. The flame was smoky and the lamp had a tendency to plug at the tip and go out. A 50 per cent dilution with N. hexane (or with naphtha) gave results that were very low. A solution of 1 cc stove oil + 5 cc N. hexane gave fairly good results, but the use of such a 16 per cent stove oil solution multiplied any error in solution analysis by 6 in calculating the sulfur content of stove oils. It was thus desirable to develop a diluent such that a 50 per cent stove oil solution in diluent could be burned to give satisfactory results.

After many trials, a satisfactory diluent for stove oil to provide a good burning mix was developed. This diluent consisted of 25 per cent acetone + 75 per cent natural gasoline, (by volume). Table 2 gives the distillation range and other physical data on this gasoline and the mixed diluent. The acetone in the diluent gave an increased volatility plus extra oxygen content which reduced the smoking tendency of the flame, and the plugging tendency of the lamp tip. Burning tests and sulfur analyses were run on stove oils using 50 per cent diluent (by volume) in the burning mixtures. The results are given in Table 3.

The use of this diluent with heavier distillate materials did not prove so satisfactory. Twenty-five per cent (by volume) distillate, 75 per cent diluent mix was used, the extra diluent being necessary to give sufficient volatility and prevent smoking. Burning was erratic, however, and flame tended to burn alternately low and in high puffs. Results for sulfur were somewhat erratic and usually high. Several remedies were tried.

(1) The use of less acetone to give a lower vapor pressure and less flame puffing tendency. A mix of 12.5 per cent (by volume) acetone to 87.5 per cent natural gasoline was used as a diluent with better results.

(2) Limiting the hot zone of the lamp tip to a section close to the tip end—by wrapping a coil of copper wire around top ¼-in. of lamp with outer strands of wire loosely coiled. (See Fig. 1). This radiated much heat away from lamp which formerly traveled down wick tube, causing irregular volatilization and puffing of lamp. This also was a help. Of greater help was the method finally adopted, of cooling wick tube of lamp up to ⅛-in. of end by wrapping a piece of damp tissue around wick tube, occasionally adding a few drops of ice water to the tissue while lamp was burning.

(3) Redesign of lamp. A new lamp was constructed with a larger (1 mm bore) wick tube. The upper end of wick tube was formed in a slight cup shape, (by blowing a small bulb in the end of the wick tube and cutting most of the bulb away). A new 1 in. wick of No. 40 white cotton thread was inserted ¾-in. into top of wick tube just before each new sample was burned. (See Fig.

*Fletcher Oil Company, Wilmington, California.

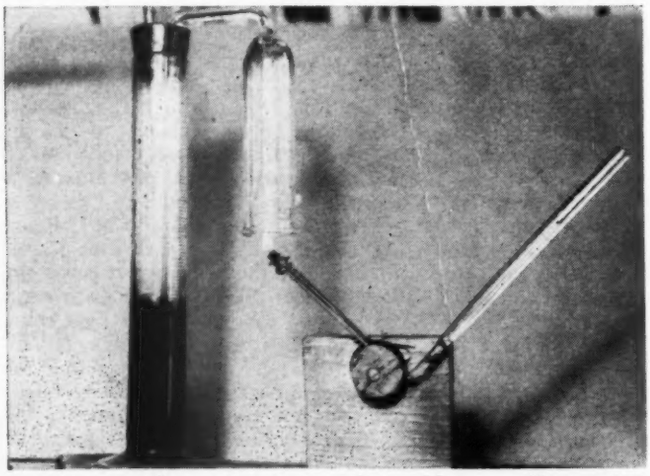


FIG. 1. Absorber used to test gasolines of known sulfur content.

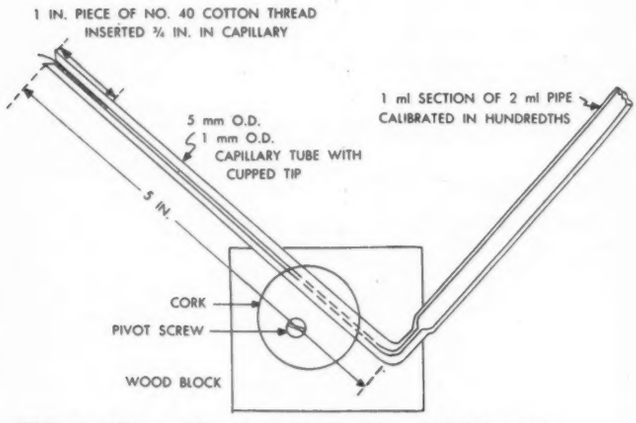
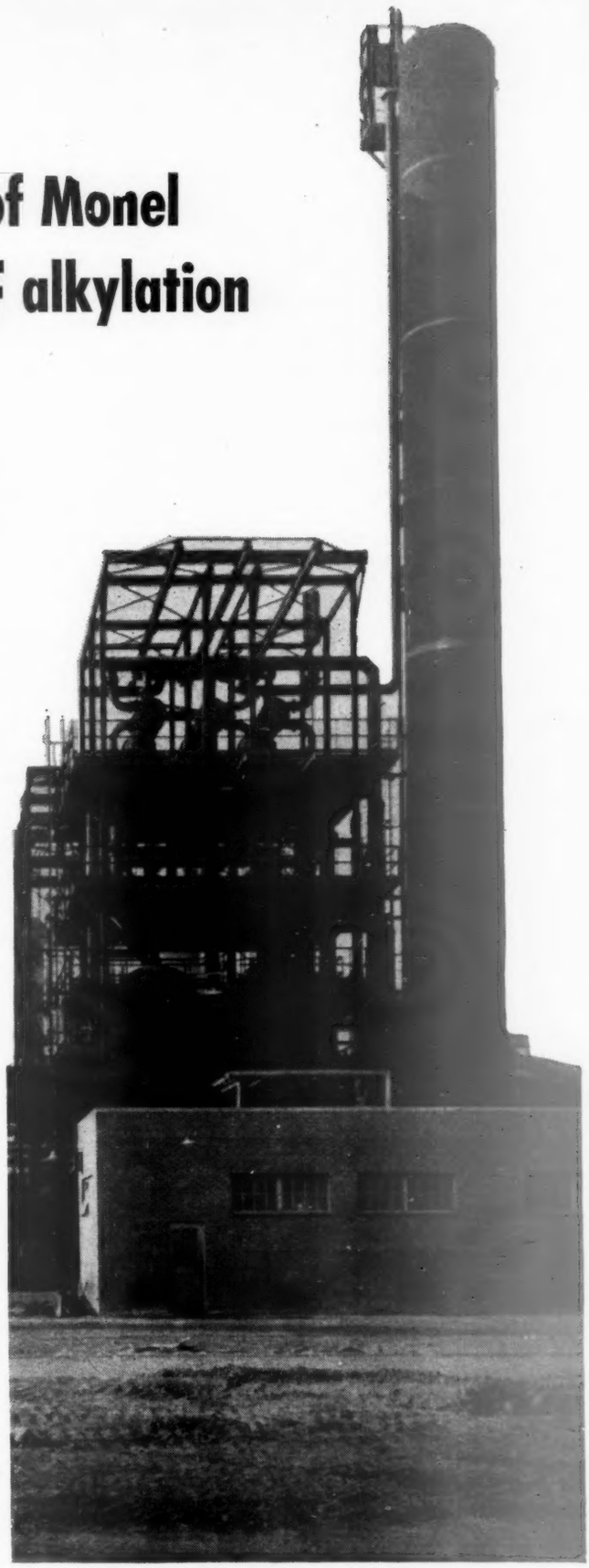


FIG. 2. Micro sulfur lamp for burning distillate mixes.

The "where" and "why" of Monel in HF alkylation



Where there is a wide range of acid concentrations ... Monel® is usefully resistant to *all* acid concentrations. That's most important, for example, in acid regeneration equipment where concentrations may vary from anhydrous to 38% solutions.

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Where velocity might cause excessive corrosion... Monel is relatively unaffected by velocities that increase the corrosion rates of other metals. For this reason, Monel is advantageously used in valves, pumps, pipe lines, and for bubble caps and linings in HF distillation columns.

Where high strength is needed... "K"® Monel has all of the corrosion resistant advantages of Monel plus high strength. It is therefore most useful in parts such as pump shafts and valve stems.

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Where could Monel be most useful to YOU? Chances are Monel could be used at many points in your HF processing units to decrease corrosion and improve operations. Consult INCO'S Corrosion Engineering Section. They are always glad to help you.

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2). The larger bore prevented accumulation of heavy ends and plugging. The cup shape provided a larger hot area to aid in complete vaporization. This lamp gave a good, steady, smoke free flame about ¼-in. high, with complete volatilization and combustion of even very heavy distillates, the damp tissue being used to cool the wick tube and help prevent puffing.

With these improvements, series of tests were conducted. Typical results of these tests are given in Table 3.

Attempts to burn mixes of crude oil plus diluents in this lamp and in the gasoline lamp met with failure, however. The flame was of a very sputtery nature and lamps would soon plug near the tip and go out.

Procedure

Apparatus required. Absorber as described and shown in Fig. 1. Micro lamp similar to that of Fig. 1, but with modifications as in Fig. 2.

Reagents: 10 ml micro buret, calibrated in .05 ml and with fine tip delivering .01 to .02 ml drops.

Reagents: Approximately O.IN iodine solution in methanol. Dissolve 12.7 gm of iodine in 1 liter of C.P. methanol.

Approximately .05 N aqueous solution of sodium thiosulfate—contains 12.5 gm $Na_2S_2O_3 . 5H_2O$ per liter of water.

Special Achromatic Indicator: Dissolve .2 gm Methyl red + .1 gm methylene blue in 200 ml alcohol.

Starch indicator solution: 2½ gm soluble starch per liter of water. Dissolve starch in a little cold water—pour into boiling water and boil for a few minutes. Cool and make up to volume.

Burning Diluent—12½ per cent by volume acetone plus 87½ per cent by volume low sulfur S. R. gasoline of approximate qualities as given in Table 2.

Method

(1) Prepare burning mix by making approximately 50/50 or 75/25 (by volume) blend of diluent plus distillate (for most distillates above 30 gravity use a 50/50 mix—for under 30 gravity, use 75 per cent diluent, 25 per cent distillate). If gravities and temperatures of materials are known they may be blended by accurately pipeting the materials. Otherwise weigh the materials since the weight per cent of the distillate must be known to calculate the sulfur content accurately.

(2) Fill the clean lamp (with fresh wick in place) and mix and start it burning.

(3) Prepare absorber by adding 20 drops (about 0.4 ml) of methanol—iodine reagent plus 4 drops of starch indicator, to about 15 gm of pure cracked ice (zero blank). Add distilled water to the 30 cc mark.

(4) After burning at least .2 ml of mix in lamp, adjust lamp so that a steady flame about ¼-in. high is obtained.

(5) Place stopper with chimney in place in absorber and start suction. Read lamp to nearest .001 ml and place beneath chimney. Record lamp reading.

(6) While this burning is taking place prepare another absorber. After burning 0.1 to 0.2 ml of mix, (note A) remove lamp from beneath chimney, reading carefully to the nearest .001 ml and recording the reading. Transfer chimney to second absorber, read lamp, place beneath chimney, and burn as before.

(7) Repeat this procedure to give 3 or 4 solutions for analysis.

(8) Pour solution from absorber to clean flask, rinsing absorber with about 10 ml of distilled water.

(9) Discharge remaining starch-iodine blue with a few drops of .05N thiosulfate.

(10) Add 5 or 6 drops of special achromatic indicator solution and titrate to first permanent faint green color with .02 N sodium hydroxide solution. Record reading. Run titrations on other solutions.

(11) Run a blank on reagents, pulling air through the reagents in the absorber for the same length of time as an average burning. Titrate blank as above.

Note A. If starch iodine blue starts to fade, quickly remove lamp and read. If solution fades to colorless, discard solution and burn less material next time.

Note B. For very accurate work, all burning mixes should be made by weight, weighing to an accuracy of 0.1 per cent.

Note C. When through with lamp, it should be cleaned by rinsing with several .5 ml portions of diluent, allowing diluent to flow through lowered wick end of lamp.

Calculations

A % sulfur in mix burned:

$$1)\quad \%S_1 = \frac{V \times F}{v \times d}$$

% sulfur in original distillate = $\%S_2$

$$2)\ \frac{\%S_1 - B}{\%S_2} = \frac{A}{100}$$

Whence

$$4)\quad \%S_2 = \frac{100(\%S_1 - \frac{(100 - A) \times \%S_d}{100})}{}$$

$$\text{And 4a)}\quad \%S_2 = \frac{100(\%S_1) - (100 - A)(\%S_d)}{A}$$

V — Vol. of NaOH titration (ml) (less blank V for reagents)

F — Factor for NaOH

$\%S_1$ = % sulfur in mix.

v — ml of mix burned

d — specific gravity of mix at lamp temperature.

$\%S_d$ = % sulfur in pure diluent.

A = wt % of distillate in mix.

B = % sulfur due to diluent in mix.

$$3)\text{ and } B = \frac{(100 - A) \times \%S_d}{100}$$

A typical calculation is given. (From first analysis in Table 3).

$\%S_d = .013$

$A = 53\%$ $\quad \%S_1 = .342$

From 4a):

$$\%S_2 = \frac{100(\times .342) - (47) \times .013}{53}$$

$$\%S_2 = \frac{34.2 - .61}{53} = \frac{33.6}{53}$$

$$\%S_2 = .634$$

Samples No. 1 and 2 were known mixes of methanol plus butyl mercaptan. Sample 4 is a N. hexane—butyl mercaptan blend. All calculations were made using the theoretical factor of .0160 for .02 N NaOH (not the experimental factor as determined in reference 1).

Discussion of Results

Table 1.

Results shown in Table 1 show the superiority of the new capillary tube absorber in giving complete reaction of the SO_2 with iodine to form $H_2SO_4 + 2HI$. Results of sulfur analysis of blends of known sulfur content show that very nearly the theoretical per

TABLE 1. Comparison of absorber efficiencies in lamp sulfur analysis.

Sample	Known sulfur content	Per cent S found: New capillary tube absorber Ave.			Per cent S found: B—old absorber (Modified Ethyl Corp. absorber) Ave.		
IV	.120	.120	.123	.120	.115	.107	.123
				.117		.116	
I	.327	.324	.320	.327	.305	.302	.328
			.324			.294	.295
II	.108	.104	.102		.102	.099	
			.106			.105	

TABLE 2. Physical properties of materials.

Material	Gravity °API	Distillation range IBP	10%	50%	90%	E.P.	Rec.	R.V.P.	Flash	% sulfur content
Natural gasoline	58.0	140	190	228	290	350	98.5	3.6	...	.020
Diluent A 25% acetone (a) 75% natural gasoline	56.4	120	132	210	284	342	98	7.3	...	.013
Diluent B 12.5% acetone (a) 87.5% natural gasoline	57.4	120	142	226	292	345	97	5.9	...	.018
Stove oil A	35.0	356	386	422	487	544	98	...	134	*.634
Stove Oil B	38.3	370	401	440	482	522	98.5	...	130	*.278
Cutter Stock A	18.8	392	414	526	680	(Cracking)	93	...	...	*.687
Cutter Stock B	26.3	466	523	608	717	724	96	...	...	*2.56
Vacuum gas oil	20.4	588	650	676	736 @ 80% then crack.			S. F. Vis. @ 122 F = 31 secs.		*1.24

(a) Volume %.
* Sulfur — average of 2 or more shell quartz tube sulfurs.

cent of sulfur present was found. This new absorber then has these advantages:

1) Nearly perfect absorption and reaction.
2) Much easier manipulation.
3) Ease and economy of construction.

Table 3

Sulfur analysis results of the various materials given in Table 3 show that the rapid lamp method for sulfur gives good accuracy for a wide range of distiilate materials. The column of figures for "Sulfur content of blend" gives representative figures and shows a very good degree of consistency, especially in view of the small amount of materials burned. It will be noted that this rapid method gives results that are very slightly higher than the average results obtained by the Shell Quartz Tube method, particularly for distillates of higher sulfur content.

TABLE 3. Comparison of methods of sulfur analysis of materials in Table 2.

Material	Blend used (wt. % of distillate)	Amount of blend burned (ml)	Sulfur content of blend (ml)	Sulfur content of distillate material: Rapid lamp method Ave.	Rapid lamp method Ave.	Shell quartz tube
Stove oil A	53% in diluent A	.120	.342			
Mixed thermal cracked +S.R. Stove oil 35.0 API gravity		.100	.350	.642		.634
		.110	.345			
Stove oil B (straight run stove oil) 38.3° API gravity	52.6% in diluent A	.140	.155			
		.150	.157	.284	.278	.270
		.130	.153			.295
Cutter stock A (18.8° API gravity) Boiling range 392—680+°F.	29.2% in diluent B	.100	.216			
		.100	.210	.684	.687	.676
		.080	.216			.705
		.100	.210			.681
Cutter stock B (26.3° API gravity) Boiling range 466—724 F.	27.7% in diluent B	.085	.724			
		.095	.713	2.62	2.54	2.52
		.100	.733			2.60
		.080	.728			
Vacuum gas oil (20.4° API gravity) Boiling range 588—736+F.	27.6% in diluent B	.100	.355			
		.110	.363	1.26	1.24	1.22
		.112	.362			1.26
		.120	.364			

This method has the obvious advantage that once an acurate blend has been made, a number of burnings and analyses may be quickly made, giving more data for greater assurance of the correct value for sulfur content.

Summary

A rapid lamp method for analysis of medium and heavy petroleum distillates for sulfur content is presented. An improved absorber and micro lamp of special design is described. A table of typical results is presented that shows that this method gives results of good accuracy. This method, however, will not give good results on crude oils or residua.

Acknowledgments

The author wishes to thank the management of Fletcher Oil Company for permission to publish this paper.

References

1. Rapid Method for Determination of Sulfur in Gasoline; W. R. Battles, The Pet. Eng'r., Nov., 1953, page C-47.

Short Cut to Correlation Index

K. A. HARPER*

The Bureau of Mines Correlation Index seems to be gaining rapidly as a means of characterizing petroleum stocks with respect to aromaticity. Unfortunately computation of correlation index is somewhat unhandy when using the equation. Tables presented by W. L. Nelson, O. & G. J. *52* No. 22, 229 (October 5, 1953) are one means of simplification. This equation is as follows:

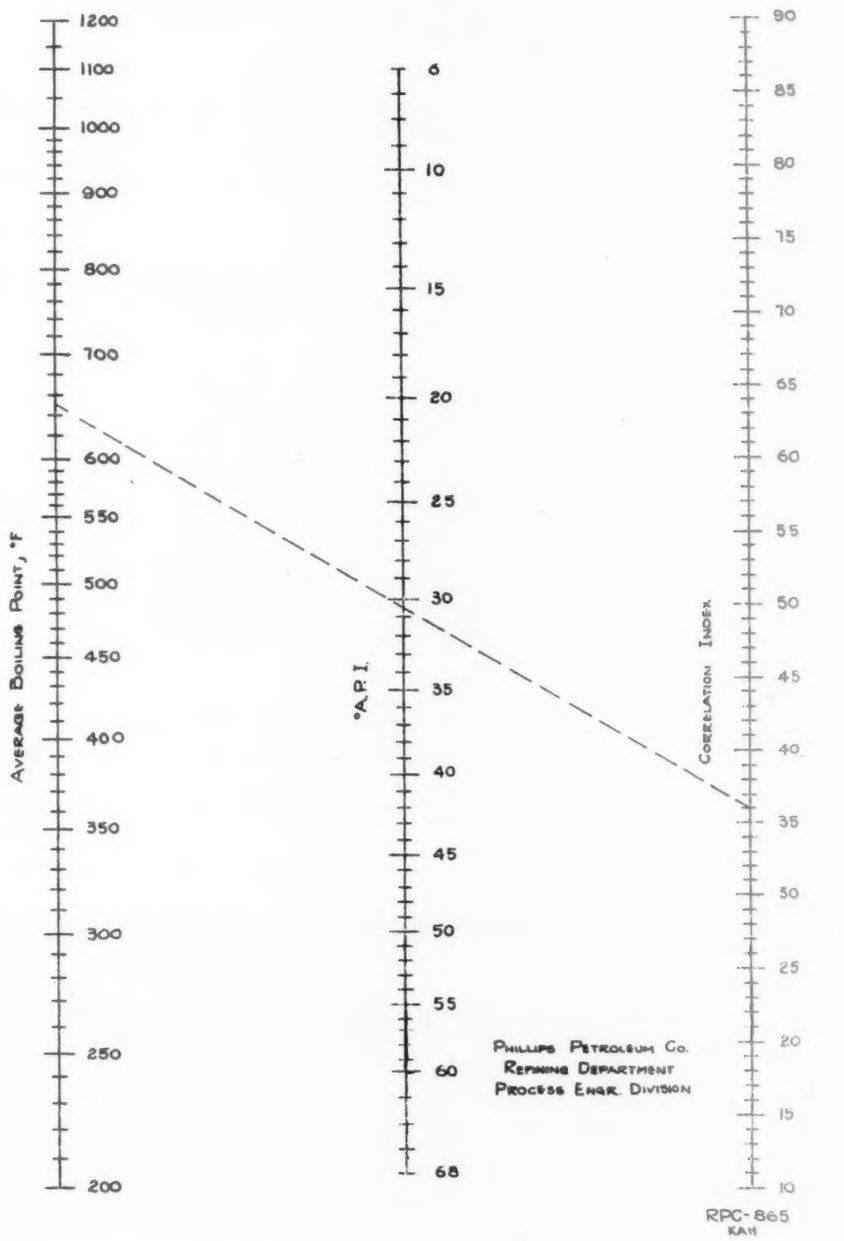
$$\text{C. I.} = \frac{48460}{^\circ\text{K}} + 437.7\ \text{Sp. G} - 456.8$$

It can also be written,

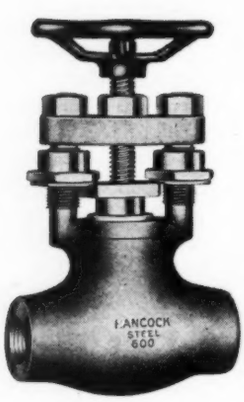
$$\text{C. I.} = \frac{87552}{^\circ\text{R}} + \frac{67029}{131.5 + \text{A.P.I.}} - 456.8$$

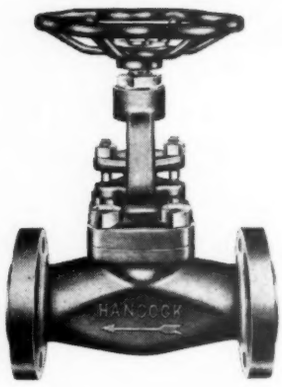
The accompanying Nomograph has proved to be a valuable time saver for everyone using the correlation index. An example is shown for 650 BP and 30.5 deg API giving 36.0 CI. The exact value is 35.8. This is typical of the nomograph accuracy. Since 3 deg error in boiling point or 0.1 deg API would give the same error in correlation index the nomograph is considered satisfactory. It has also been common practice to simplify calculations by using 50 per cent point in place of the average boiling point. No attempt has been made to determine the loss of accuracy due to this short cut. If, however, this is done continuously the trends should be consistent.

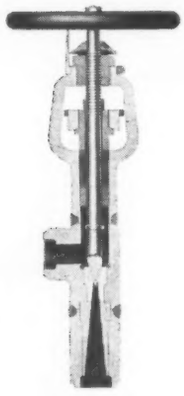
*Phillips Petroleum Company.



for the economy of quality...

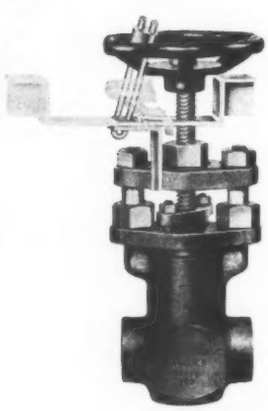




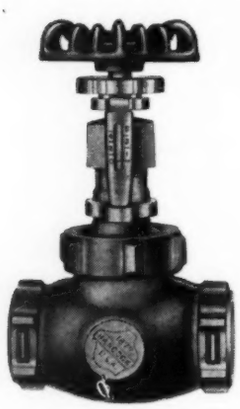


600# through 2500# Hi-Pressure Drop Valves. For continuous blowdown service. Combine orifice, shut-off and index in a single unit. **No Bonnet Joint Design. Sizes:** ¾", 1" and 1½". **Orifice Sizes:** ⅛" minimum; 1" maximum. **Connections:** Screwed or Socket Weld Ends.

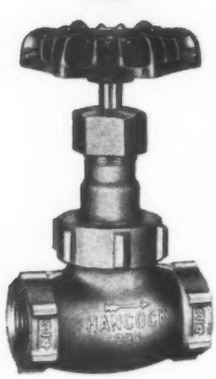
600# Steel Valves. Dependable, trouble-free in the severest services. **Sizes: No Bonnet Joint Design** (left)—¼" through 2". **Bolted Bonnet Design** (right) — 1¼" through 2". **Types:** Globe and Angle. **Connections:** Screwed, Socket Weld and Flanged Ends. **Service Ratings:** For all pressures up to 850 psi at 750° F. — O.W.G. 2000#, 100° F.



Water Column Shut-Off Steel Gate Valves. Combine a simple, positive locking and signaling device. Red flag indicates at a glance whether valve is open or closed. **Sizes:** ¼" through 2". **Connections:** Screwed and Socket Weld Ends. **Service Ratings:** For all pressures up to 800 psi at 775° F.—O.W.G. 2000# 100° F.



"Flocontrol" Valves. 3-in-1 design combines variable orifice, shut-off and index. BRONZE: **Types:** Globe and Angle. **Sizes:** ¼" through 2". **Connections:** Screwed Ends. Available in 150# and 300# series. STEEL: **Types:** Globe and Angle. **Bolted Bonnet and No Bonnet Joint Designs. Sizes:** ¼" through 4". **Connections:** Screwed, Socket Weld and Flanged Ends. Available with 150#, 300# and 600# series flanges.



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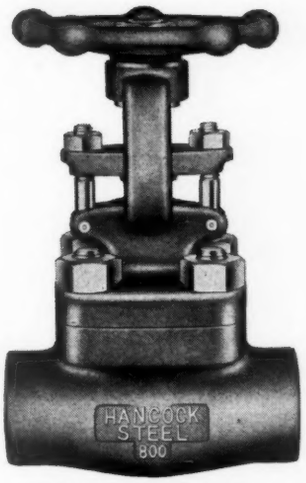
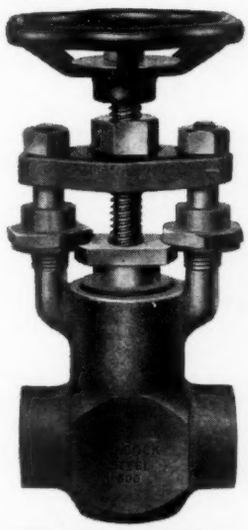


800# Steel Gate Valve,
Bolted Bonnet Design.



800# Steel Gate Valve,
No Bonnet Joint Design.

800# Steel Gate Valves. More than meet the requirements of process piping systems. **Bolted Bonnet Design. Sizes:** ¼" through 2". Type 950 illustrated at upper right offers these alternate trims: (a) Cobalt-Chromium Tungsten Alloy, Hard Facing—"420 Brinell"; (b) 18-8% Stainless or 20% Nickel, 8% Chrome; (c) Monel; (d) Hastelloy. **Connections: Flanged Ends** — for all pressures up to 800 psi at 775° F.—O.W.G. 1440 psi, 100° F. Screwed and Socket Weld Ends—for all pressures up to 800 psi at 775° F. — O.W.G. 2000 psi, 100° F. **No Bonnet Joint Design. Sizes:** ¼" through 2". **Connections:** Screwed and Socket Weld Ends — for all pressures up to 800 psi at 775° F. — O.W.G. 2000 psi, 100° F.

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XUM

Continuous Wax Moulding Quadruples Man-Hour Output†

Machine has been operating about three years; designed to mould and package petroleum waxes continuously and automatically to avoid contaminating wax

RAY SHANNON*

Magnolia Petroleum Company's continuous wax moulding machine has been in operation for approximately three years. Basic design objective was to develop a machine that would mould and package petroleum waxes continuously and automatically, with a minimum of personnel and maintenance and to do it in such a manner as to avoid any contamination of the wax.

RISING costs and the need for additional wax moulding capacity prompted Magnolia Petroleum Company, in 1948, to review its wax moulding procedures. The batch moulding process then in use is described by Jennings, Beard, and Kalichevsky.[2] Various other wax moulding procedures then available were investigated and rejected as not representing a substantial advance over the batch plate-and-frame process. Finally, a manufacturer of continuous chocolate-moulding machines, the J. W. Greer Company, of Cambridge, Massachusetts, was approached with the idea of modifying one of their machines to mould petroleum waxes. Resulting continuous wax moulding process, which has been a subject of considerable interest and discussion,[1,2,3] was developed through the joint efforts of the two companies. The moulding machine proper was designed and built by the J. W. Greer Company; the packaging equipment was supplied by the J. L. Ferguson Company of Joliet, Illinois, and the conveyor system was developed by the Alvey Conveyor Company, St. Louis, Missouri.

The basic objective was to design and construct a complete wax moulding process which would mould petroleum waxes continuously into slabs, package the slabs into cartons, mark the cartons, and deliver them to freight cars or trucks. An alternative operation was to be provided, allowing the packaging equipment to be by-passed and the wax slabs loaded directly in bulk form into freight cars or trucks. All operations were to be automatic, requiring as few personnel as practicable, and all machine components were to be designed for low maintenance.

†Presented at the 8th Petroleum-Mechanical Engineering Conference of the American Society of Mechanical Engineers, Houston, Texas, September 28-30, 1953.

*Junior engineer, Magnolia Petroleum Company, Beaumont, Texas.

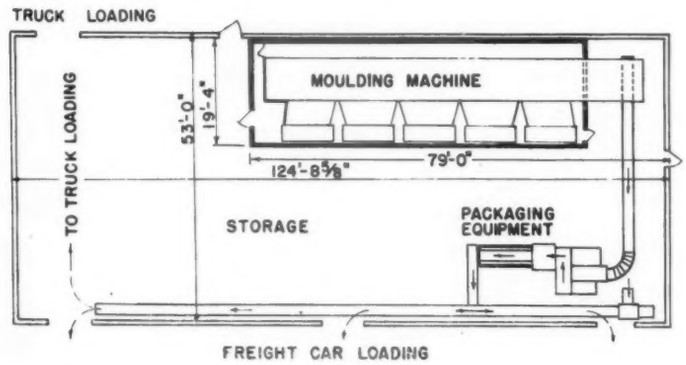

FIG. 1. Plan of wax moulding facilities.

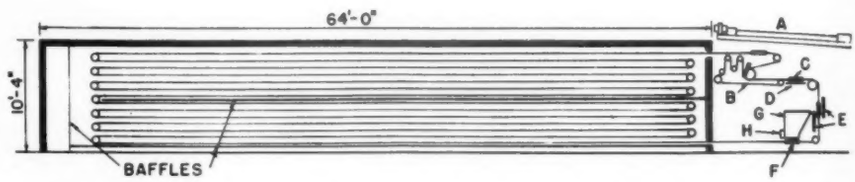

FIG. 2. SIDE view of moulding machine. Legend: A, wax tempering column; B, dumping conveyor; C, inverted pan in dumping position; D, discharge slat conveyor; E, pan heaters; F, pan approaching filling position; G, wax hopper; H, depositor.

Equipment

Wax moulding, packaging, and conveying equipment is housed in a building approximately 53 ft by 125 ft as shown in Fig. 1.

Wax Moulder. The wax moulder consists of a wax "tempering" system, pan mould filling system, pan mould conveyor chain, cooling facilities, and wax cake dumping and discharge facilities.

Wax tempering columns (see Fig. 2) consist of a set of double-pipe heat exchangers through which molten wax is passed for the purpose of adjusting its temperature to the value desired. Steam-heated water is admitted to the annular space between the pipes. Automatic controls proportion the steam and water to achieve the correct wax outlet temperature, the exact value of which varies with the type of wax being moulded. The inner pipes are equipped with rotating scrapers which continually scrape the wax off of the pipe wall.

The pan filling system consists of a hopper containing molten wax, six wax depositors and six depositor valves. The hopper is water jacketed to maintain the correct wax temperature. Pan moulds pass underneath the hopper in groups of six and are filled with wax while they continue to move. The depositors consist essentially of six variable-stroke plunger pumps with the plungers timed to operate in sequence with the passage of pan moulds underneath the hopper. The six depositor valves provide passages for the wax to flow from the hopper into the cylinders on the up-stroke of the pistons, and from the cylinders into the pans on the down-stroke of the pistons. The six valves are operated in unison by a cross-bar actuated by an air cylinder. Diffuser plates on the bottom side of the depositor valves direct the streams of molten wax into the pans without excessive splashing.

The groups of pans are carried in frames, six pans to a frame, which in turn are conveyed by two roller conveyor chains travelling at a speed of approximately 6.7 fpm. There are 418 frames, making a total of 2508 pans.

The pans are 2 in. deep, 11¾ in. wide and 19 in. long and are normally filled with 11 lb of wax. The pans containing the molten wax enter an insulated refrigerated room approximately 19 ft wide, 64 ft long, and 10 ft high (Fig. 2). Pans travel back and forth on the tiered construction in the cooling space and leave at the top through the same end that they entered. Normal residence time in the room is approximately two hours. The conveyor chains are driven by a 10-hp electric motor through a main clutch, reduction gear, and chain and sprocket arrangement.

Provision was made in the design of the machine to transfer the pan frames to the next higher level at each end of the cold room while keeping the pans level and the wax undisturbed, as any shaking or vibration of the wax during the cooling process would mar the appearance of the cakes. Pan frames are attached to the conveyor chains by pivot pins in the center of each end of the frame. The four corners of the frames are equipped with rollers that travel on guides to maintain the pans in a level position. Chain sprockets of the correct pitch diameter elevate the frames to the next higher level as the chain passes over them. The rollers on the leading edge of the frame travel over curved guides while those on the trailing edge are engaged by stabilizing sprockets which rotate at the same speed, and have the same pitch diameter, as the conveyor sprockets.

Cooling in the refrigerated room is furnished by five Carrier direct-expansion ammonia air-handling units. Air is circulated over the wax pans as shown in Fig. 3. A 120-ton reciprocating ammonia compressor is situated in an adjacent refrigeration plant. Normal temperature in refrigerated room is 20-30 F.

As the pan frames leave the refrigerated room each pan is passed over a spring-loaded roller, which flexes the bottom of the pan and loosens the wax cake. Pans are then inverted against a wide conveyor belt which moves at the same speed as the pans, and the cakes fall out of the pans, onto the belt. Wax shrinks upon solidifying thus simplifying the problem of getting it out of the pans. The cakes are carried to the dumping station (see Fig. 5) where they fall onto a slat discharge conveyor which is at rest while the cakes are being delivered to it. Immediately after a group of six cakes have dumped, the slat conveyor is set into motion and delivers the six cakes out of the machine onto a continuously-moving conveyor belt, which conveys them to the packaging equipment or to bulk loading.

Empty pans are heated by electric heaters before being re-filled. This avoids sudden cooling of a thin film of wax in the pans.

Packaging Equipment. Packaging equipment automatically packages five 11-lb wax cakes to a carton and can handle four to five cartons a minute. The equipment consists of a grouping plunger, case opener, case loader, glue machine, and compression unit.

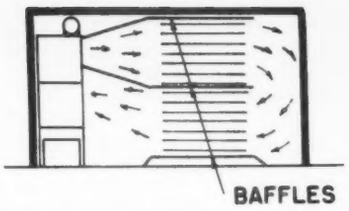

FIG. 3. CROSS section of moulding machine.

The grouping plunger stacks the cakes five high and delivers them to the case loader. To begin operations, the grouping plunger is manually preloaded with four stacks of cakes, one stack consisting of four cakes, the next of three, the third of two, and the fourth of a single cake. These cakes rest on spring-loaded gates, and as cakes are fed into the machine they pass under the pre-loaded cakes. As soon as five cakes have entered, they are elevated past the spring-loaded gates and thus one cake is added to each stack such that there are now five stacks consisting of five, four, three, two, and one cake respectively. The grouping plunger then advances the entire group of stacks one cake width, delivering the five-cake stack to the case loader. The unit is thus returned to its original condition.

Knocked-down cardboard cases are loaded manually into the magazine of the case opener. The case opener removes the bottom case blank, opens it, and places it in position to receive five cakes of wax from the case loader. After the case loader has pushed five cakes into the case, it trips the clutch on the glue machine which applies glue to the flaps on the case, folds the flaps, and delivers the case to the compression unit. This unit holds each case under compression for approximately two minutes to allow the glue to set.

Conveying Equipment. Conveyors have been utilized to minimize the manual handling of the cakes and cartons of wax. Portable gravity conveyors are utilized to move the product from the loading conveyor into freight cars or trucks. It is only necesary to stack the cartons or cakes in the car. When cakes are being shipped in bulk form, the packaging equipment is by-passed and the cakes enter a wax cake stacker which stacks them four high and delivers them to the loading conveyor. The wax cake stacker is a modification of a semi-automatic packaging machine which was built by Magnolia for use in packaging cakes while awaiting delivery of the automatic equipment.

Operation

Fully refined paraffin wax is the only type of wax that has been moulded in Magnolia's machine. Studies have indicated that amorphous wax may be moulded with the addition of a complete filling system (tempering column, hopper, and depositors) to avoid contamination of the waxes. These additions have not yet been made.

Wax is maintained in a molten state in a feed tank outside of the building and is pumped through the tempering columns to the wax hopper. The pump is regulated by a float control arrangement in the hopper to maintain a fixed level of wax. The wax is filtered twice in its passage to the hopper to maintain a fixed level of wax. The wax is filtered twice in its passage to the hopper as an added safety precaution. The tempering column operates automatically, either heating or cooling the wax as required to deliver it to the hopper at the correct temperature.

Melting point of the wax is the controlling factor in the moulding process. The melting point of the waxes moulded varies from 120 F to 140 F. It has been found by experiment that the wax should be deposited in the pans at a temperature 20-30 F above the melting point and should be cooled to approximately 20 F below the melting point before being dumped. Dumping temperature is referred to the center of the cake. Failure to provide sufficient residence time results in cakes with soft centers and impairs their dumping characteristics. The cakes must be completely solidified in order to contract sufficiently to separate easily from the pan moulds, which are provided with slightly sloping sides to aid in dumping. Too much cooling, i.e., lowering the cake temperature too far below the melting point results in brittle cakes which tend to crack when subjected to shock loads in the conveying and packaging equipment.

The speed of the pan frame conveyor chain can be varied from 3.66 fpm to 14.85 fpm with a normal operating speed of 6.7 fpm. Variation in chain speed thus allows for variation in wax moulding rates. Also subject to control is the cake weight which may be varied by changing the stroke of the depositor pistons. Normal cake weight for the Magnolia machine is 11 lb., although cakes weighing 9 lb 6½ oz are sometimes moulded. One surprising feature of the machine is the accuracy of cake weights. While the machine was being built by the manufacturer, Magnolia designed and built an automtic cake weighing device which would weigh each cake coming from the machine and automatically reject those which were over or under weight. When the moulding machine was put into operation, however, the device failed to reject any cakes. By manually weighing sample cakes and applying the methods of statistical quality control it was discovered that the inherent accuracy of the six wax depositors is such that the weight variation of 11-lb cakes is within one ounce. Because of this accuracy, use of the automatic rejecting device has been discontinued. Periodic checks are made of the cake weights, however, using statistical quality control, for assurance that the machine is maintaining its accuracy.

In Fig. 4 are presented data on the performance of the moulding machine. Curve A, showing the relation between cycle time (the time required for one

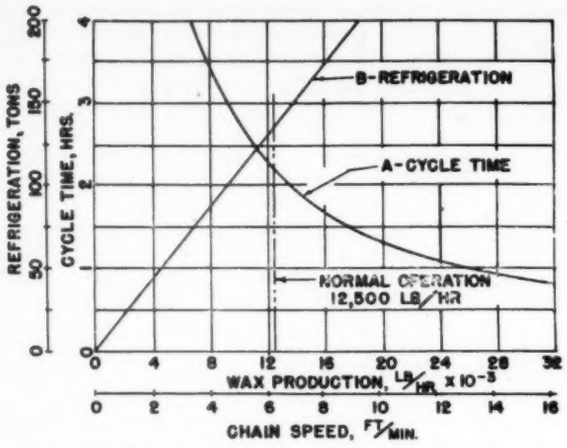

FIG. 4. RELATIONS between refrigeration, cycle time, and wax production, based on moulding 11 lb cakes. Refrigeration is based on actual heat removed from wax.

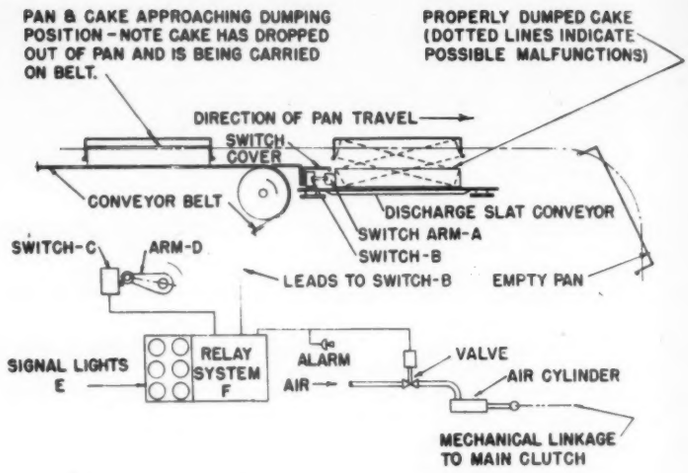

FIG. 5. DUMPING malfunction alarm — schematic. Dumping malfunction is sensed by failure of switch arm A to have switch B open during time arm D has switch C closed. Relay system F sounds alarm and opens air valve, thus admitting air to cylinder and stopping machine. Relay locks and is reset by hand. Signal lights E signal which pan has failed to dump.

pan to travel completely through the machine and return to its original starting place, which would be slightly longer than residence time inside the cold room) and rate of wax production, was calculated for 11-lb cakes. This curve is determined by the mechanical characteristics of the machine (e.g., pan frame conveyor chain length, variation in chain speed, size of sprockets, etc.) and the weight of the wax cakes, and a similar curve exists for each cake weight. Curve B shows the relation between the amount of refrigeration required and rate of wax production. This is also a calculated curve, based on removing 130 Btu per pound from the wax during the cooling and solidifying process, and shows the actual amount of heat removed, allowing for no losses. The slope of Curve B will vary greatly with waxes of various melting points.

Curves indicate that the capacity of the machine could be increased greatly if sufficient refrigeration is provided, since the chain speed may be varied from 3.66 to 14.85 fpm as stated previously. This is true only in a limited sense, and it has not been found practical to increase the rate much above 12,500 lb per hour or a chain speed of approximately 6.3 fpm. Higher speeds are used when moulding cakes lighter than 11-lb, but when moulding 11-lb cakes it has been found that the sudden stopping of the conveyor chain which occurs if any of the cakes fail to dump properly (see Modifications) causes wax spillage and disturbs the partially solidified cakes, if the chain is travelling at the higher speeds.

A comparison of the manpower requirements for the new moulding process and for the old plate-and-frame batch process is presented in Table I.

Maintenance

Modifications. Operating experience and maintenance problems have indicated the desirability of several modifications and revisions which have been made on the machine. Certain modifications have been performed by Magnolia while others were done with the collaboration of the manufacturer.

It was discovered that rather extensive baffling is required in the cold room to direct the flow of refrigerated air over the pans in such a way as to secure adequate cooling of the wax without any sub-cooling. As shown in Fig. 3, air is directed across the top seven layers of pans and returns to the air-handling units across the lower seven layers. A baffle was installed underneath the bottom layer to force all of the returning air through the spaces between the pans, and a wall was installed across the end of the tiered construction (see Figs. 1 and 2) to prevent short-circuiting of the air around the end. It was found that the cakes in the end pans nearest the air coolers were receiving too much cooling, and deflectors were installed to deflect the cold air over most of the width of these pans.

Some difficulty has been experienced due to the failure of cakes to dump properly. Originally the machine was equipped with a vibrator to shake the pan frames when they had reached the dumping position to insure that all of the cakes had been loosened. This imposed severe shock loads on the mould pans and pan frames, and quite possibly contributed to a series of weld failures which were experienced with the pan frames. In an effort to secure a milder means of loosening the cakes in the pans, two sets of stationary spring-loaded rollers were installed to flex the bottom of each pan twice in its passage from the cold room to the dumping station. Neither system is foolproof, however, and cakes occasionally fail to dump, particularly if the dumping temperature is not correct. If a cake remains in the pan, a fresh 11 lb charge of wax will be deposited on top of it, resulting in wax spillage. If a cake falls partially out of a pan it will become jammed in the machine, necessitating stopping the machine to clean out the wax.

In an effort to minimize the consequences of a dumping failure, the system shown schematically in Fig. 5 was developed. The basic approach was to develop a device which would automatically stop the machine if any cake or cakes failed to dump, and to signal which cake or cakes failed. Six single-pole double-throw limit switches (B, Fig. 5) were installed with operating arms A protruding in such a manner that each of the six wax cakes which fall onto the discharge slat conveyor will operate one of the switches. The normally-open contacts in these switches are connected to individual signal lights; thus when the wax cake operates the switch, the light for that cake signals that the cake has been dumped properly.

The normally-closed contacts in switches A are wired together in parallel and the combination is connected in series with the cam-operated limit switch C. Switch C is operated by Arm D which makes one revolution while the pans travel one pitch distance. Switch C is closed for a short time immediately before the discharge slat conveyor is set in motion. If all six cakes have dumped properly the normally-closed contacts in switches A will be open when switch C is closed, and the operation of the machine will not be interrupted. If, however, any cake or cakes fail to dump, one or more of the switches A will be closed when switch C is closed, and the relay system F will be energized. This will sound the alarm and actuate the valve on the air cylinder, the plunger of which is connected to the main clutch

TABLE 1.

	Batch	Continuous moulder
1. Capacity, lb/hr of wax having avg ASTM melting point of 130 F	4,200	12,500
2. Operating personnel per 8 hr shift:		
Operator	—	1
Operator helper	1	2
Machinist (trainee)	—	1
Labor	8	3
Total	9	7
3. Capacity, lb of wax per man-hour	466	1,785

on the machine. Thus the machine is stopped. The reset is operated manually, and it locks in place, silencing the alarm and releasing the air pressure in the cylinder. The operator then has manual control over the main clutch, and starts the machine after the malfunction has been corrected. As soon as the machine is started, Arm D moves away from switch C which then opens and allows the relay system F to return to normal.

It is of interest to note that a wax cake may fail to dump in a number of ways, two of which are shown by dotted lines in Fig. 5. If the trailing edge of the cake sticks in the pan, the corresponding switch will not be operated and the alarm will function. But if the leading edge of the cake sticks in the pan, the trailing edge will drop down and operate the switch, thus signalling that the cake has dumped. The pan continues to move to the right and will drag the cake away from the switch arm during the interval of time that switch C is closed, causing the alarm to operate.

The discharge slat conveyor which operates intermittently to move the groups of six wax cakes out of the machine and onto a continuously-moving conveyor, and the continuously-moving conveyor, were originally driven from a gear case which received driving power from the main drive system. This transmission system consisted of a combination of gear and chain drives with a clutch to provide intermittent motion to the slat conveyor, and required considerable maintenance. Several failures occurred, due probably to high loads imposed in starting the slat conveyor. This driving system was replaced with an independent motor-driven gear case of rigid design, which is satisfactory.

The original tin-coated plain steel slats in the slat conveyor required renewal after approximately 2½ years. The coating failed due to abrasion caused by the wax and the slats themselves deflected and took a permanent set due to the loads imposed on them. They were renewed with slats fabricated from Type 304 stainless steel and stiffened by the addition of a web welded to the under side of each.

The mould pans, also originally tin-coated plain steel, began to show signs of failure after approximately eight months of service. The tin coating failed in an area of the inside bottom which was subjected to the stream of molten wax when filling. It is believed that thermal shock caused the failures. All 2508 pans have been renewed with pans fabricated from Type 302 stainless steel.

The pan heaters that heat the pans during their passage from the dumping station to the filling position (Fig. 1), were subjected to wax deposits falling out of the pans and off the slat conveyor. These were electric radiant sheathed element heaters, and the reflectors became blackened by the wax deposits. The heaters were renewed and the design modified to incorporate strip heating elements inclosed in reflectors which are formed in steps.

Some difficulty has been experienced with the depositor valves. These consist of a cast iron block and a steel piston. Passages are provided in the block and the piston, the piston being rotated to align one set of passages while the depositor is being filled and another set when the wax is discharged into the pan. These parts require very close fits, and any wear would allow wax to by-pass or spill, and destroy the accuracy of the cake weights. Failure has been experienced due to galling. As a temporary expedient the pistons have been undercut, built up with alloy weld metal, and re-machined. Consideration is being given to renewing the parts with corrosion-resistant non-galling material.

Routine Maintenance. It has been found that the equipment requires the full time services of a machinist trainee for maintenance purposes. Cleaning, lubricating, renewing small parts are primary maintenance procedures.

A considerable amount of manpower is consumed in maintaining the gluing equipment, the condition being aggravated by the fact that the cartons are glued with water-proof glue. It is necessary to clean the glue machine thoroughly at the end of each shift since the glue becomes very hard and abrasive upon drying. Items such as glue rolls, scrapers, and glue pump parts have a limited life due to the abrasiveness of the glue. Some investigation has been made into the possibilities of coating such parts with a material such as Teflon, and also into the possibilities of modifying the machine to eliminate as many moving parts as possible.

It is believed that the new continuous wax moulding system, although still in the process of development, constitutes a substantial advance over the old plate-and-frame batch moulding process. The new machine has a capacity of 1785 lb of wax per man-hour compared to 466 lb per man-hour with the old process, and the following additional advantages have been obtained: (1) Decreased cost of moulding wax, (2) increase in wax moulding capacity, (3) improved appearance and cleanliness of wax cakes, and (4) more uniform cake weights.

Acknowledgement

The writer wishes to express his appreciation to his colleagues at Magnolia who assisted in the preparation of this paper, and to the Magnolia Company for permission to prepare and publish it.

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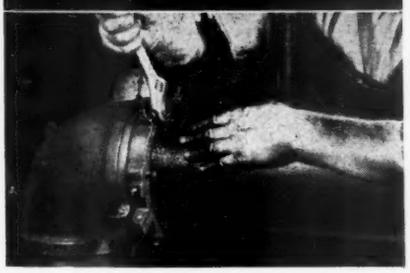

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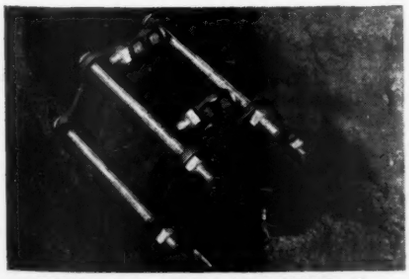

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REFINING AND PETROCHEMICAL

PERSONALS

James W. Bateman, technical assistant to the manager of Continental Oil Company's manufacturing department, has been selected to receive a 1954-55 Sloan Fellowship at the Massachusetts Institute of Technology, Cambridge, Massachusetts, it is announced by Continental Oil's president, L. F. McCollum. Bateman is the third Conoco man in five years to receive a Sloan Fellowship.

Established by the Alfred B. Sloan Foundation, Inc., the Sloan Fellowship Program for Executive Development was founded in 1938 to train promising young technical executives in the broader phases of industrial management and to prepare them for future positions of business leadership.

A graduate of the University of Pittsburgh, Bateman joined Conoco in 1952.

M. T. McCants

M. T. McCants has been appointed plant manager for the new refinery to be constructed by the Great Northern Oil Company at Pine Bend. He was previously associated with the Great Southern Chemical at Corpus Christi, Texas, as general plant superintendent.

Holder of a B.S. degree from Rice Institute and a M.S. degree from Massachusetts Institute of Technology, McCants began his refinery career with Humble in its Baytown refinery.

Walter J. Jameson has been appointed superintendent of the Santa Maria refinery Union Oil Company plans to build in San Louis Obispo County, California.

Jameson joined Union Oil in 1940, as a chemical engineer. He was graduated from Stanford University in 1938 with an A.B. in chemical engineering and received his M.S. from the Massachusetts Institute in 1940. He has held positions as assistant superintendent of the Cut Bank refinery in Montana, assistant superintendent of distillation at the Oleum refinery, and was assistant superintendent of cracking of the Los Angeles refinery and later assistant superintendent of the operations department.

J. H. Selby, formerly district manager for Oronite Chemical Company in Dallas, has been named assistant to the eastern vice president, H. E. Bramston-Cook. In his new capacity, Selby will be responsible for bulk sales of Oronite alkane and Oronite's detergent alkylate.

David G. Braithwaite, formerly assistant vice president and production manager of the catalyst division, has been named a vice president of National Aluminate Corporation. He will continue to head production activities of the catalyst division in addition to assuming new management duties.

Braithwaite moved to the catalyst division as production manager from the company's ion exchange division, and was named an assistant vice president in February of 1953.

Fred Powell has been appointed assistant general manager of Standard Oil Company of California's manufacturing department. He previously headed the subsidiary, California Research and Development Company, which has been dissolved following completion of its assignments for the Atomic Energy Commission.

A graduate of the University of Washington, Powell joined Standard in 1925. He was general manager of the El Segundo plant until his appointment as president of CR&D in 1950.

Christian de Guigne has been elected to the new position of chairman of the board of the Stauffer Chemical Company. De Guigne had been president for the past 8 years. **Hans Stauffer,** formerly executive vice president and general manager, was elected president. **John Stauffer,** vice president and secretary has taken on the added responsibilities of chairman of the new executive committee.

R. C. Wheeler was reelected vice president and **Christian de Dampierre** reelected treasurer. **James W. Kettle** was elected controller.

J. G. Wilson, formerly chief engineer at Shell Oil Company's refinery at Wood River, Illinois, has been appointed manager of the manufacturing engineering department at the company's head office in New York. He succeeds W. F. Court who is retiring. Wilson, a graduate of Michigan University, joined Shell in 1933, as an assistant engineer. He was named chief engineer at Wood River in 1952.

James A. Middleton has been named assistant general refinery superintendent of the mechanical section of Mid-Continent Petroleum Corporation's refinery. **Laron D. Stewart** was promoted to assistant general refinery superintendent, process section. **Pierce M. Reynolds** succeeds Stewart as chief process engineer.

Middleton, a graduate of Arizona University, joined D-X in 1935 as general laborer. He later became a draftsman and was promoted to chief designing engineer in 1941. At the time of his present appointment he was chief engineer.

A graduate of Tulsa University, Stewart was employed as a process engineer by the company in 1947. He became chief process engineer in 1951. He was formerly chief chemist with British American Oil in Canada and did crude oil evaluation for W. L. Nelson, Tulsa.

Reynolds joined D-X in 1948 as a process engineer. He was senior process engineer until his present appointment. Before joining the company he served with Danciger Oil and Refining Company and with Root Petroleum Company.

F. M. Files is being transferred from Salt Lake City to McGregor, Texas, as manager of manufacturing at Air Force Plant No. 66 operated by the rocket fuels division of Phillips Petroleum Company. **George F. L. Bishop,** previously superintendent of Phillips Okmulgee, Oklahoma, refinery will replace Files as northwest division refining superintendent at Salt Lake City. Replacing Bishop is **L. H. Vautrain,** assistant superintendent of the Sweeny, Texas, refinery.

Files joined Phillips in 1930 upon graduation from Austin College. He was administrative assistant to the vice president in charge of refining prior to being appointed northwest division superintendent in 1951.

A graduate of West Texas State College, Bishop, joined Phillips in 1935. He has been superintendent at Okmulgee since 1949. Vautrain, a graduate of Louisiana State, has been assistant superintendent of the Sweeny plant since 1950.

Jack L. Rune

Jack L. Rune has been named director, vice president, and executive assistant to the operating head of Champlin Refining Company, Enid, Okla. He was formerly Rocky Mountain regional manager for The Chicago Corporation, which in April purchased Champlin and its subsidiary, Peppers Refining Company.

A graduate of Kansas University, he joined The Chicago Corporation in 1944.

In Enid, Rune will be executive assistant to **G. E. Leverton, veteran Champlin comptroller** who has been named vice president in charge of operations. **Earl Baldridge,** executive vice president of The Chicago Corporation, is Champlin president.

John Ewbank has joined the patent department of Houdry Process Corporation. A graduate of Purdue University and the University of Indiana Law School, Ewbank has had experience in chemical research, patent litigation, preparation of patent applications, and was recently engaged in private law practice in Philadelphia. His present position with Houdry entails prosecution of patent applications and related work.

Jan G. Schaafsma has been advanced to the post of assistant manager for General Petroleum Corporation's laboratories department.

Schaafsma joined General Petroleum in 1934 upon receiving his Master's degree in chemical engineering from the California Institute of Technology. He was first employed as a junior inspector and, prior to his promotion, was assistant laboratory manager.

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Storage Waits Legislation

Underground storage of natural gas, which makes possible the operation of pipe lines at capacity during the season of light demand and provides needed supplies for use in winter-demand months, will go forward on a larger scale when certain legal and political tangles are cleared up. The United Mine Workers and others oppose the practice on the grounds of safety and this has tied up federal legislation that would permit condemnation of subsoil rights for gas storage. A dozen or more states already have condemnation laws.

Many areas of heavy consumption have underground storage facilities and numerous others, both along the Atlantic Seaboard and West Coast, await official action in the matter of gas storage.

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Turndown Recommended

If recommendations of Federal Power Commission attorneys are adopted permits will be refused to both major applicants seeking to supply natural gas to the Pacific Northwest. The applicants are Pacific Northwest Pipeline Corporation and Westcoast Transmission Company, Inc. In a 49-page opinion staff counsel told FPC that neither company has shown it has enough natural gas to serve the market. Pacific Northwest planned to serve the area from the San Juan Basin of New Mexico and Colorado and Westcoast Transmission from the Peace River area of British Columbia and Alberta.

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Contractors Organize

Further evidence that Canada is becoming more and more a pipe line country is the formation of the Pipe Line Contractors Association of Canada. Permanent headquarters are in Edmonton. The association is patterned after the Pipe Line Contractors Association of America and the two groups will work in cooperation when occasion requires.

E. W. Costello of Calgary is president of the new association, G. A. Wilkinson of Vancouver, first vice president, R. K. Banister of Edmonton, second vice president, and William Tesluck of Edmonton, treasurer. Directors include G. P. Kennedy of Vancouver, R. Jernigan and C. E. Callahan of Edmonton. One of the association's purposes is the maintenance of industry standards.

Super Inch Expanding

Pacific Gas and Electric Company is increasing capacity of its 500-mile transmission line from the California-Arizona border connection with El Paso Natural to the San Francisco Bay area by looping its existing 34-in. line with new 34-in. pipe. Near completion is an 80-mile section in the Mojave desert and planned for later in the year is a 27-mile section. When completed, PG&E will have nearly 800 miles of 34-in. in service at an investment of $98,700,000. Capacity will be increased from 600,000,000 to 700,000,000 cu ft per day.

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FPC to Study Gas Prices

The Federal Power Commission is considering the advisability of adopting rules on automatic escalation and "favored nation" clauses in purchase contracts of interstate pipe lines. Interested parties may file briefs until July 1. Oral argument will be heard September 9 of this year.

Production and gathering are not covered by the Natural Gas Act, but FPC wants to determine whether provisions for automatic price increases have "any reasonable relation to economics" of producing, gathering, and transporting natural gas.

FPC points out that it could regulate this matter, even though not covered in the Natural Gas Act, by ruling that contracts containing such provisions are not acceptable evidence of supply for a new certificate, or by disallowing payments under escalation provisions in existing contracts that are not related to improved service.

★ ★ ★

Appalachian Short Course

Mark V. Burlingame, vice president in charge of operations for the Natural Gas Pipe Line Company of America and also the Texas-Illinois Gas Pipe Line Company, will present principal address at the Appalachian Gas Measurement Short Course, August 23-25 at West Virginia University, Morgantown, West Virginia.

C. G. Moorhead, measurement superintendent of Hope Natural Gas Company is general chairman of the Short Course.

A. M. Hutchison, measurement superintendent of the Ohio Fuel Gas Company is program committee chairman.

Subjects to be covered in this 14th Annual Short Course will include fundamentals of gas measurement and special sessions on automatic control instruments, planning and design of installations, pressure regulators, orifice meters, large capacity meters, domestic meters, motor valves and auxiliary measurement instruments. Approximately 100 instructors have been chosen to teach the special phases of these subjects.

Further information on this course may be obtained by writing Professor R. E. Hanna of the University of Morgantown.

★ ★ ★

Gas Property Merged

The Federal Power Commission has authorized Olin Interstate Corporation, of New York City, to acquire by merger and operate all pipe line facilities of Interstate Natural Gas Company, of Monroe, Louisiana. The authorization, however, is conditioned to require Olin Interstate to record the acquisition of the pipe line company at net original cost, and to prevent Olin Interstate's assumption of a $32,000,000 debt incurred by it and its first parent, Olin Industries, Inc., in acquiring Interstate Natural's stock.

Interstate Natural's pipe line system, located in Louisiana and Mississippi, will continue to be used and operated in the same manner as in the past. Upon completion of the merger, Olin Interstate's name will be changed to Olin Gas Transmission Corporation.

Olin Interstate now owns over 99½ per cent of Interstate Natural's stock, acquired at a cost of about $40,000,000.

★ ★ ★

Coal Pipe Line Planned

Work on a 100-mile, 11-in. pipe line designed to carry crushed coal will begin within eight months, according to plans announced by Pittsburgh Consolidation Coal Company. The $10,000,000 line will be built between the company's Cadiz, Ohio, strip mine, and a point on Lake Erie, near Cleveland, adjacent to the Cleveland Illuminating Company's power plant. The line, scheduled for operation in 1956, will handle 4000 tons of coal daily in a 50-50 water and coal mixture. Pressure of near 1000 psi will be used. Coal particles will not exceed ⅛-in. Reduction in freight rate will be from current $3.07 per ton to about $1.25 per ton between two points.

XUM

There's more to instrumentation than instruments

Instruments can do wonders, if they're given the chance. But some one has to put them to work in the most effective way. And that's where Honeywell Application Engineering steps in.

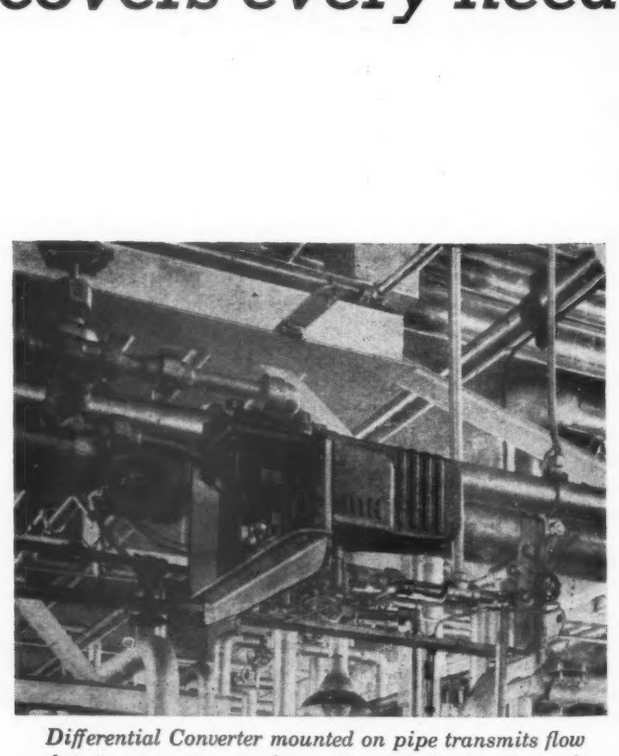
This service is one of the most important plus values you get in Honeywell instrumentation. It's a teamwork job. And every member of the team is an expert in his own field. Engineering begins right in your own plant, where a Honeywell field man digs out the vital facts about your process. He sits down with your engineers, production men and instrument technicians . . . and finds out everything he needs to know about what needs to be measured or controlled, to what accuracy, and under what conditions.

Then the problem goes to Honeywell's Application Engineering staff. Here's where you'll find groups of instrumentation specialists for every major industry. One group, for example, is devoted to the control problems of the metalworking industry. Another handles ceramic applications . . . another chemical . . . until together they cover the whole gamut of modern processes. These men know their specific field from years of first-hand experience. They're thoroughly familiar with the techniques of processing and the ways that instrumentation should be applied.

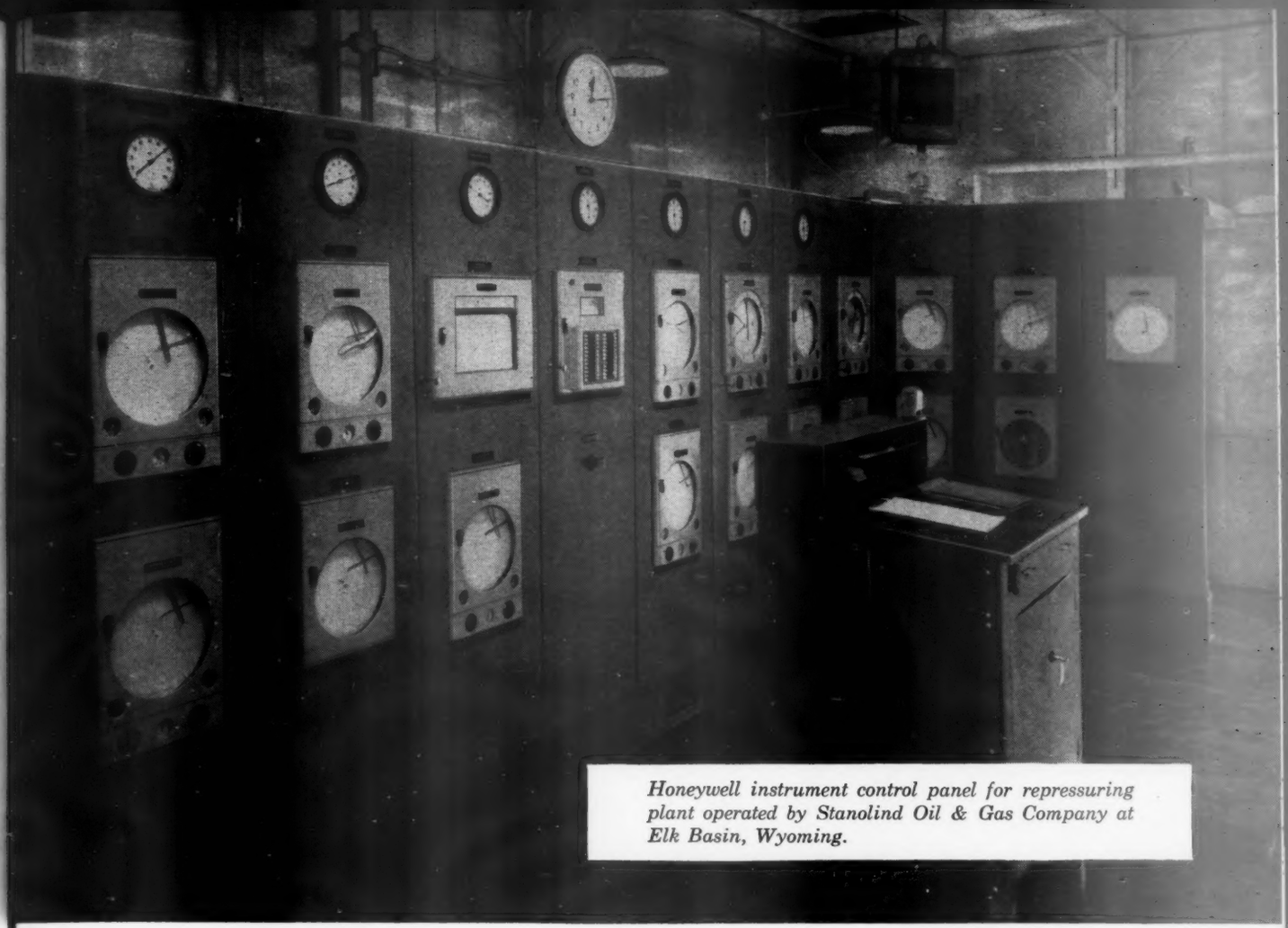
Honeywell Application Engineers develop detailed recommendations for the complete installation. They determine the most effective instruments, primary elements, types of control and valves for every phase of measurement and control. They add switches, signals, interlocks and other accessories which their experience indicates are needed in the interest of safety and convenience. Then they combine all components into a complete system—whether it involves a single instrument or a whole panel—that is designed for peak production efficiency, simple maintenance, and greatest convenience to operators.

This service saves time by doing engineering work that would tie up your own staff for many hours. And it pays off in assuring the excellent performance of which Honeywell instruments are capable.

Complete Honeywell instrumentation *covers every need*



Differential Converter mounted on pipe transmits flow data to a remote recorder on the central control panel.



Honeywell instrument control panel for repressuring plant operated by Stanolind Oil & Gas Company at Elk Basin, Wyoming.

# of field processing plants

PLANNING a field processing plant? You don't need to "shop around" for instrumentation for the specialized applications of this kind of unit . . . because the broad line of Honeywell instruments encompasses practically every measuring and controlling assignment. Of particular interest to gasoline plants are:

***ElectroniK* indicators, recorders and controllers** . . . the standard of precision and dependability, these instruments can measure dozens of different variables. The selection includes circular chart and strip chart models, and the Precision Indicator for rapid checking of up to 48 separate temperature points.

Brown Thermometers and Pressure Gages . . . available in practically unlimited choice of ranges and with various forms of pneumatic control.

Flow Meters . . . evenly graduated type for accounting and square root scale type for control applications. Electronic integrator gives fast, accurate flow totalizing. Choice of electric and mechanical meter bodies.

Differential Converter . . . a rugged but sensitive pneumatic balance transmitter for remote measurements of flow, and differential pressure.

Working with these instruments is a full selection of primary elements, control valves and accessories . . . from which Honeywell specialists design custom-fitted systems for individual process requirements. And behind these products stands a nationwide service organization that is always ready to help you, wherever and whenever you need instrument service.

Your nearby Honeywell sales engineer will be glad to discuss your own process control application . . . and he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

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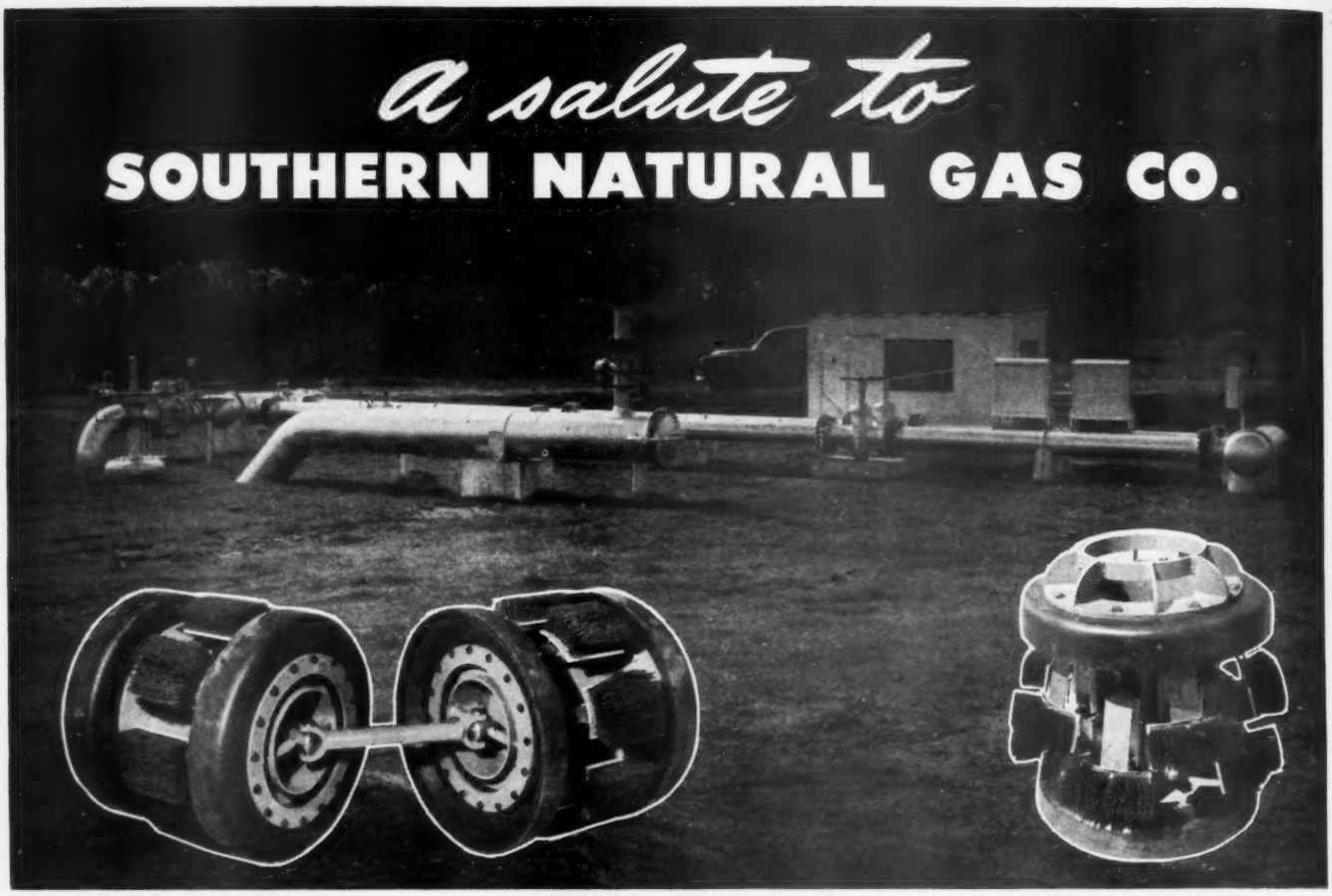
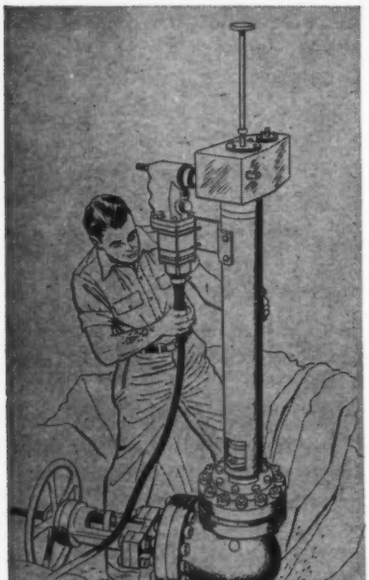


WmSON 24" TYPE GP-3 PIG

SCRAPER TRAP INSTALLATION AT WINVILLE COMPRESSOR STATION

WmSON 16" TYPE UG-1 PIG

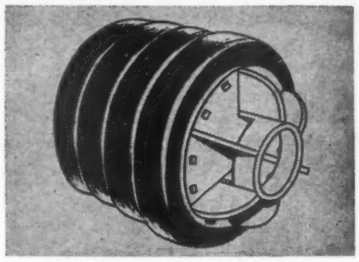


Wm-SON-HILLCO TAPPING MACHINE

For making lateral connections to the pipeline . . . without shutdown . . . against line pressures up to 1,200 psi.

A Feature of Southern Natural's New Pipe-Line System is Provision for ON-STREAM PIGGING . . . to maintain maximum capacity without shutdown or loss of gas.

Williamson is proud to have provided — and serviced with factory-trained engineers — WmSON Pigs, Tapping Machine, Bushings and Insulators to meet Southern Natural's exacting requirements.



WmSON 18" LBN-4 PIG

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WmSEAL CASING BUSHINGS AND CONCENTRIC-SUPPORT INSULATORS . . .

For use where pipelines pass through right-of-way casings.

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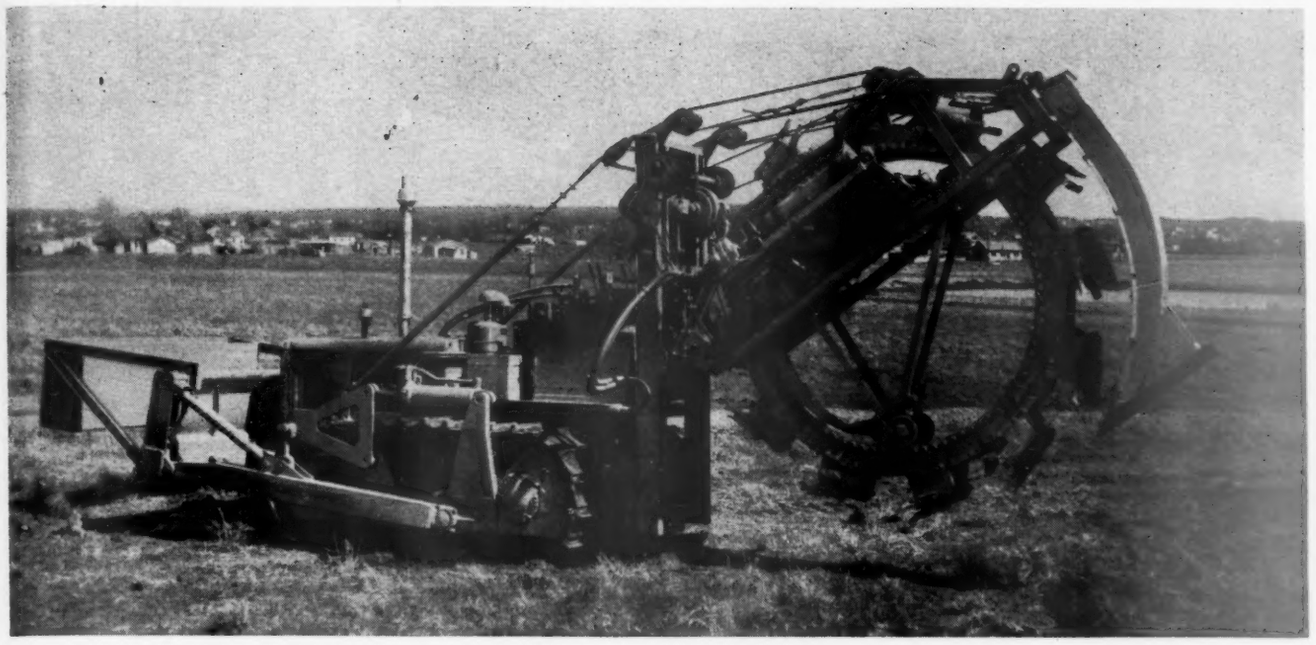


Newest addition to list of equipment that can be mounted on tractors is this ditcher.

MODERN TRACTOR EQUIPMENT

Variety of attachments makes crawler tractor most versatile unit in pipe line construction; here's a summary of the more valuable items

J. J. KEYES

VERSATILITY of the crawler tractor, its easy adaptation to a vast variety of tasks, is demonstrated clearly in the pipe line industry.

A casual glance at the jobs done for pipeliners by crawler tractors reveals an astoundingly long list. Anglefilling, backfilling, winching, ditching, pipelaying, right-of-way clearing, pneumatic drilling, bending, and many other chores are all in the day's work for the omnipresent crawler. As one pipeliner puts it, "The crawler is first on the job and the last to leave it."

The Pipelayer

A vast improvement over older methods of pipelining is the modern pipelayer with its sidebooms capable of supporting vast weights while lining up and lowering in. All-welded booms, strong brakes on both boom and load line drums, and sensitive controls permit lifting and lowering long sections of large diameter pipe without damage to wrapping. The big counter-weighted crawlers today have a lifting capacity of more than 40 tons at a 4-ft over hang with creep gear arrangement to give full power for load and boom line drums while the crawler paces with doping machine.

Detachable Ditcher

Adding to the versatility of the crawler is the recent development of a detachable ditching machine that can be mounted on a tractor in approximately 30 min. When ditching is completed, the ditching machine is detached with equal speed to make the crawler available again for the multitude of other jobs for which it is suited on any spread.

Filling

Whether it's angle filling or back filling, the crawler's famed utilitarian tool, the bulldozer blade, goes into action. The crawler tractor's reputa-

The Author

J. J. (Jim) Keyes is the pipe line construction representative for Caterpillar Tractor Company. Joining the Trackson Company of Milwaukee in 1943, his first field assignment was as district representative in the southwest territory with headquarters at Oklahoma City.

At that time, his chief concern was the sales and product development of front end shovels and pipe layers. Later, as pipe line construction activity increased, his interests moved in that direction and early in 1953 he was assigned to Peoria to devote his full time to the activities of Caterpillar in the pipe line industry. He was educated at Marquette University, Milwaukee, Wisconsin.

EXCLUSIVE

Sideboom pipelayer is most useful piece of tractor equipment for pipe line operations. Booms with pipe slings here are lowering in 26-in. pipe on Louisiana job.

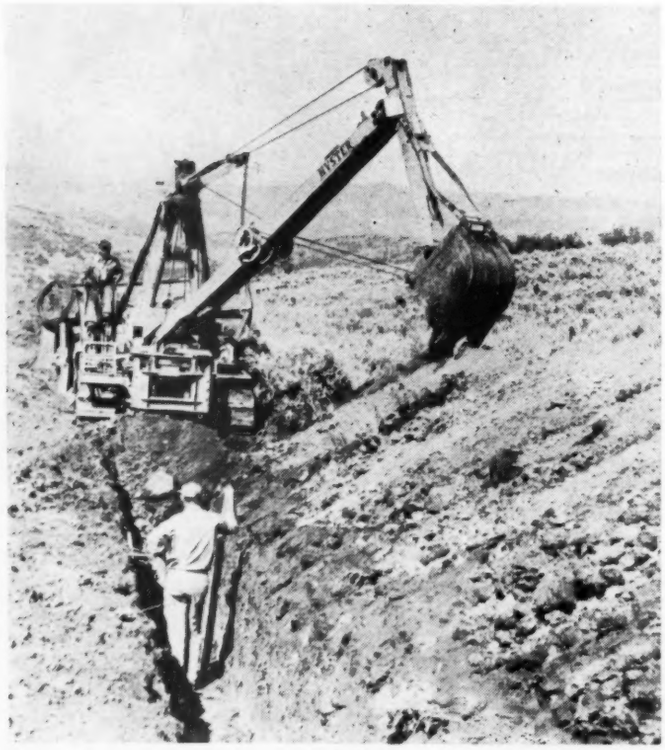
Brush rake on crawler tractor being used to clear right-of-way on Mississippi pipe line job.

tion during World War II was established because of the unbelievable feats of earthmoving it accomplished in military action. But to the pipeliner, eternally vigilant for new ways to make crawler ownership profitable, there are other means of keeping his prize workhorse busy. In addition to using dozer blades and back fillers for filling, some pipeliners have found it advantageous to mount draglines on their crawlers. Others have been equipped with a clamshell bucket and still others have mounted the backhoe on the crawler with pleasantly profitable results.

More recently, the tractor-mounted shovel has come into prominence as a tool of the pipeliners for backfilling and for lifting and loading jobs on many spreads. Advantage of the tractor-mounted shovel is the quickness with which the bucket can be removed and replaced with loading forks for handling certain types of material.

Clearing

Peculiarly, research in behalf of the agriculture industry has contributed to the efficiency of the pipeliner. Root rakes, rock rakes, and other types of landclearing tools developed to rehabilitate wooded or rocky areas for cropping, have been adopted by the



Back hoe mounted on tractor illustrates versatility of the pipeliners' "right hand." Trenching job was on Utah pipe line.

Tractor equipped with 30-ft boom and clamshell in use on trenching job.

Drilling blast holes in New Mexico. Sideboom equipped tractor tows compressors, while wagon drills are supported from boom.

Backfilling on Texas pipe line job using tractor equipped with pipe layer sideboom and angle-filler.

pipeliners in clearing right-of-way for the ditchers. Rippers capable of breaking up in-place material too hard to remove by less strenuous means, are often called upon to take the initial steps in breaking hard surface material before clearing begins. In clearing, however, the bulldozer continues to be the most popular of track-type tractor attachments.

Bending

One of the jobs calling for precision handling on any spread is bending. Bending machines mounted on track-type tractors have been used frequently and have proven to be especially useful in the more inaccessible areas where mobility over rough terrain is mandatory.

Miscellaneous

The crawler tractor's position in the pipe line industry is strengthened by the easy availability of other miscellaneous attachments. The small track-type tractor is often called upon to draw the air compressor that powers a wagon drill mounted on another crawler. On another, the compressor may be actually mounted on the tractor.

No discussion of crawler tractor attachments would be complete without mention of the *winch*. A not unfamiliar sight on any spread in rough country is a crawler tractor, anchored to firm ground by its wide tracks, and connected to a backhoe or other less mobile equipment, by a taut winch line. In some instances the winch line serves as an anchor chain. And it's a rare breed of "skinner" who has not seen a crawler winching machinery out of a swamp, up a steep incline or just rescu-

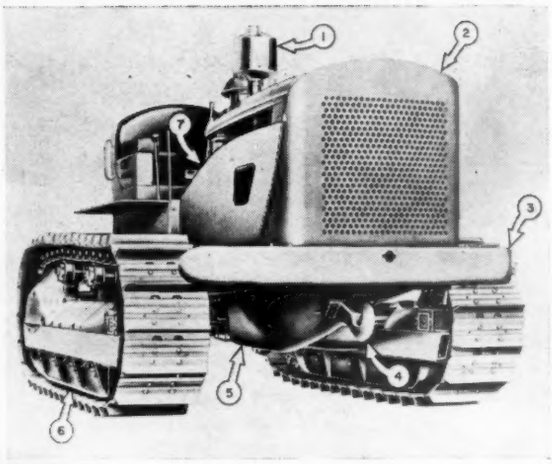
Small tractors are used for such jobs as handling portable welders. Tractor is enclosed with covers on winter job in Iowa.

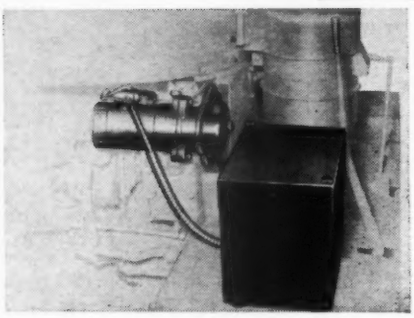
Winch-equipped tractor is useful in pulling other heavy machinery when bogged down, as in this case where clamshell digging trench on Maryland pipe line job was stuck.

XUM

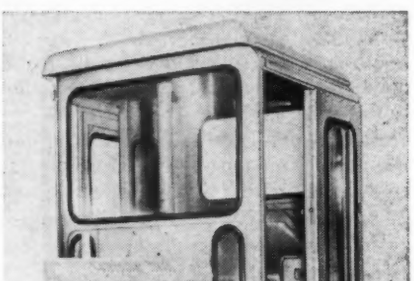
Special attachments that protect the tractor and make it adaptable for more uses:

1. **spark arrester**
2. **heavy-duty radiator guard**
3. **front bumper**
4. **front pull hook**
5. **crankcase guard**
6. **heavy-duty roller guard**
7. **upper engine guard**



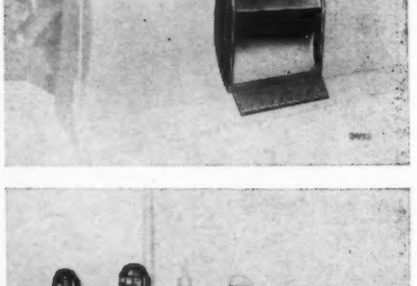


Electrical starting unit for gasoline starting engines on diesel tractors.



All weather cab provides comfort and protection for operator, year-around use of equipment for owner.

Push cup gives good in-line power application for pusher tractor, doesn't interfere with dozer characteristics. Cup also protects against blade damage.



Lights on tractor permit round-the-clock operation.

ing mud-bound wheeled equipment after a heavy rain.

The crawler tractor is often subjected to certain strenuous jobs that may in some way endanger the machine or some part of it. Or the owner may hesitate to use his tractor on a certain job for fear of damaging it. In cases such as these, special attachments may be purchased to protect the machine, and, thus, keep costly down-time due to breakage at a minimum.

Guards Radiator

For example, *a heavy-duty radiator guard* is a wise precaution against tree limbs and brush on a right-of-way clearing operation. Or, if the tractor is operating under severe conditions, an *extra heavy-duty track roller guard* will protect the track rollers from damage. Rocks and stumps also prove a working hazard and a *crankcase guard* is low cost insurance against damage to the underpart of the engine and transmission. Various types of guards are also provided to protect the tractor engine from tree limbs or branches.

Often operations are near dry underbrush, timber, or storage tanks of inflammable materials where a spark from the exhaust may prove very costly. A *spark arrester* has been developed that practically eliminated all danger from this source. And when operating near hospitals, schools or quiet zones, a *muffler* can be attached that will reduce exhaust noise.

Rain Trap Good Investment

To protect the tractor engine and to prolong its life, a rain trap on the exhaust stack is a good investment. Also engine hoods and doors and radiator shutters or curtains will help control the engine temperature when the merucry hits bottom.

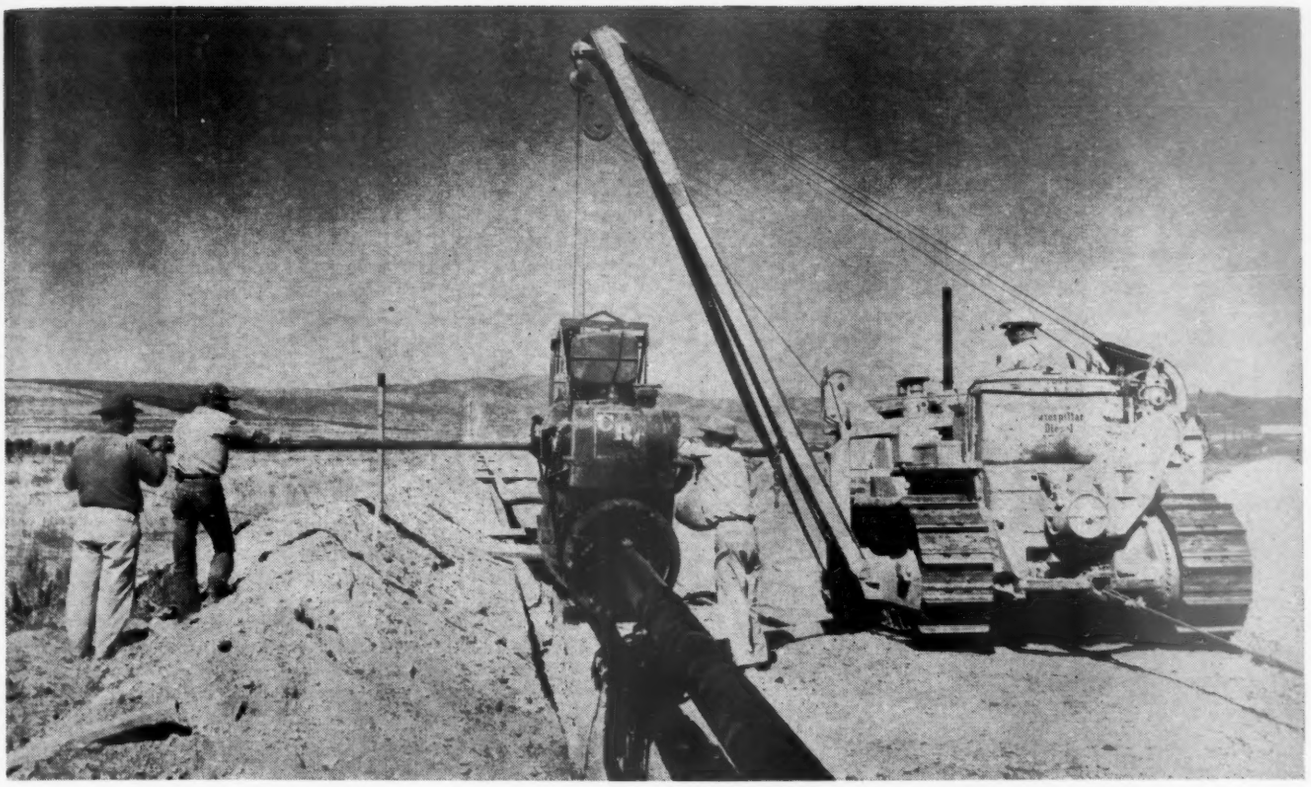
Ease Load On Air Cleaner

For unusually dusty jobs, an air cleaner pipe extension has been developed to relieve the air cleaner of some of the load and thus provide fresher air for the tractor engine. As an extra precaution against lint, chaff or leaves, a prescreener (standard precleaner combined with a length or wire mesh) is used.

Special Track-Shoes

The crawler tractor is required to travel over many types of surfaces in performing its job. Tractor manufacturers have done considerable research to provide owners with special shoes to adapt their track-type tractors to these various surfaces.

Grousers of different sizes, skeleton shoes, snow and ice shoes, street plates,



Sidebroom equipped tractor cradling pipe for cleaning and priming machine on construction job in Idaho.

and rubber shoes are but a few of the many types of shoes available for special jobs. Snow sprocket wheels and different track assemblies are also available to insure the tractor's adaptability to unusual climatic conditions.

Push Cups Helpful

Special attachments provided for construction and other jobs include push cups that give good in-line power for pusher tractors. These push cups may either be mounted to a U-frame in front of the tractor or attached directly to the dozer blade so that the tractor can be used not only as a pusher but also as a bulldozer.

A *front pull hook* is also available and may be used where heavy duty equipment is being towed and it is desirable to hook tractors in tandem. A front bumper may also be attached to protect the tractor radiator from heavy bumps or jolts.

A rear power take-off may also be attached for special jobs, or the tractor owner may obtain the doubly-useful combination of both the rear power take-off and belt pulley drive. Then there is a front power take off available for driving auxiliary equipment such as generators, pumps, and winches.

The comfort and convenience of the operator is too often overlooked in the operation of a track type tractor. The tractor manufactures realize this and provide special attachments to remedy the situation. For convenience, where a gasoline starting engine is used to start a diesel engine, an electrical starting unit may be attached to the starting engine. Or, if it is extremely cold, an ether starting aid is designed to assist the starting of the diesel engine.

For the comfort of the operator, cabs have been designed to keep out the blizzards, sharp winds and other discomforts of winter. A heater may be installed in the cab to keep the operator warm. To shield the operator from the sun and to provide shelter during showers or sudden downpours, a canopy top may be purchased.

Extra wide seats are available for the smaller tractors, and a special lower rear seat for tractors is offered where more head-room is needed. Lights, too, are available for that round-the-clock schedule that so many crawler tractor owners must maintain.

Keeping in mind three basic principles—greater protection for the tractor, greater versatility of the tractor, and greater operator comfort and convenience — the track-type tractor through more and better attachments is broadened in value as a prime mover for pipe line operations. * * *

Tractor equipped with angle-filler is useful in backfilling ditch. Equipment in picture on pipe line job in Canada.

XUM

Second of a Series

Microwave System Design

W. E. SUTTER*

EXCLUSIVE

MICROWAVE is only about five years old from the commercial viewpoint, but is already being marketed in a variety of forms. A brief description of the microwave equipment that is now available is in order before we begin the planning of an actual system.

Basically all microwave equipment consists of two parts; the radio frequency equipment, and the multiplexing assemblies. RF equipment is now available in the following frequencies:

890-940 mc
952-960 mc
1850-1990 mc
3700-4200 mc
5924-6425 mc
6575-6875 mc

The 952-960 mc band is the oldest in terms of commercial application. For years, equipment in this region has provided FM and TV stations with microwave links from the studios to their transmitters. Because of the narrow spectrum available at these frequencies, (the channel width is only 8 mc) the 960 mc equipment is most efficiently applied to relatively short systems with low channel capacity. This equipment is extremely economical and is adaptable to a wide variety of applications, such as voice communications with either code ringing or dialing service, teletype, protective relaying, supervisory control, telemetering, and remote control of VHF transmitting facilities.

Most of the microwave development that has taken place since 1948 has been concentrated in the 2000 and the 7000 mc bands. The wider spectrum space available at these frequencies meant wider channel widths that, in turn, led to the development of duplex transmissions over the same antenna systems.The advent of duplex transmissions appreciably reduced cost of microwave systems by requiring fewer antennas, less transmission line, and standard towers.

The wider spectrum space also stimulated development of time division multiplexing, which promises to provide even finer system performance than is now available.

Types of equipment available in these higher bands were specifically designed for high channel capacity systems of any length. Because a system of this type usually involves more material and greater cost, the equipment has been designed to include many extra features that make it more complicated than equipment in the 960 mc band. Higher frequency equipment might be compared to a main line throughway; where the 960 mc equipment is the feeder or spur line.

With this background one can begin to plan a typical microwave system. Of course, there is no such thing as a typical system, as each actual installation has its own particular applications. For example, a pipe line system may run in a line for miles with only a periodic spur along the way; where a power utility or police system may consist of many legs radiating from a central point. For our purpose, we will consider a system in which both applications will be found.

Initial Planning — Voice Communications

Actual planning of a microwave system involves three distinct steps, which are, to a certain extent, independent of each other. The first step consists of laying out a simple line diagram of the proposed system with terminals and desired channel facilities indicated. The other two steps, which shall be discussed at length later, deal with actual physical location of stations and propagation requirements of the system.

In laying out a diagram (Fig. 5) for our typical microwave system, first consider the voice requirements. For example, the section between the main office at station A and the district

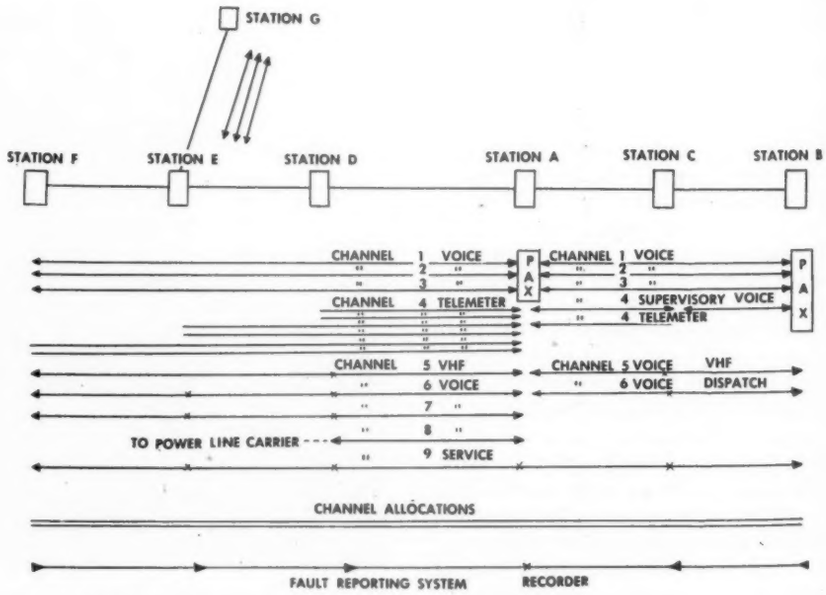


FIG. 5. Layout diagram of typical microwave system.

*Commercial microwave engineer, General Electric, Electronics Park, Syracuse, New York.

IN SPITE OF HIGH WATER

A CAT* SPREAD KEEPS ROLLING

HIGH WATER on the right-of-way has not bogged down this Bucyrus-Erie dragline powered by a rugged Cat D318 Diesel. Operating from wooden mats, the dragline continues to backfill the trench between Hawkins and Longview, Texas. Work is being done by O. R. Burden Construction Co., Tulsa, Oklahoma.

"Caterpillar equipment," reports R. M. Jones, superintendent on the job, "will last longer with less maintenance than any other equipment I've ever used."

This statement comes from experience. Up the line on this fast-moving spread, three D7s, a D8, a D8800 and a D318 are at work.

Standardization on Cat equipment is normal among pipeline men. It's normal because it's profitable. Money is earned because operators and mechanics need only know one make of machinery. Operators get more production out of it and mechanics spend less time maintaining it. Costs are cut because many parts are interchangeable. Parts inventory can be practically eliminated. And expenses fall with the use of low-cost No. 2 furnace oil. All Cat Engines burn it *without fouling*.

Ask your Caterpillar Dealer for the full, money-saving picture on standardization. Leading manufacturers of excavators, ditchers and compressors can furnish Cat Engines as original equipment. And, when it's time to re-power, it's time to see your Caterpillar Dealer.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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A WORD TO THE WISE— STANDARDIZE!

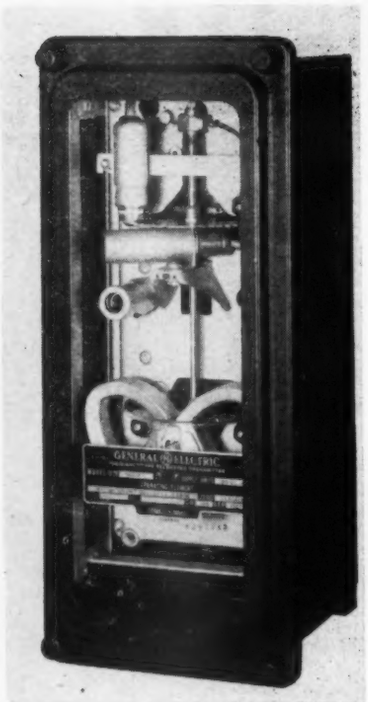


FIG. 6-A. Frequency-type telemeter transmitter.

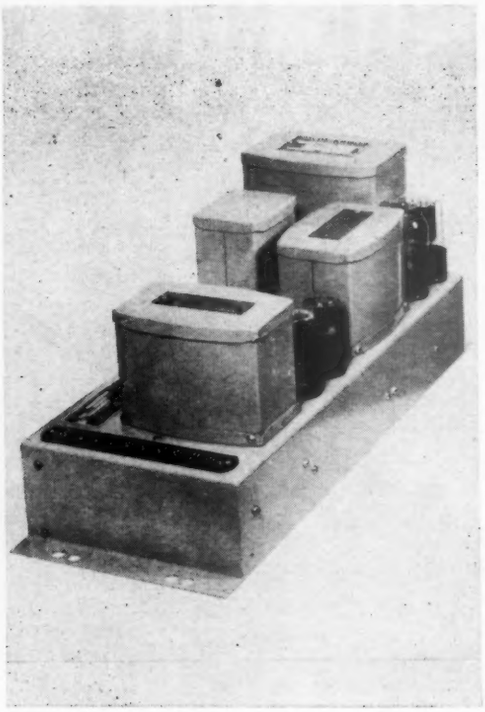


FIG. 6-B. Frequency-type telemeter receiver.

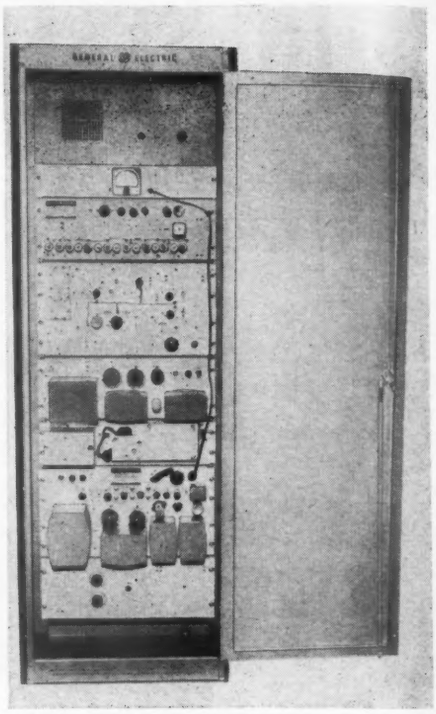


FIG. 6-C. Typical microwave equipment cabinet for fixed point-to-point control and relay application.

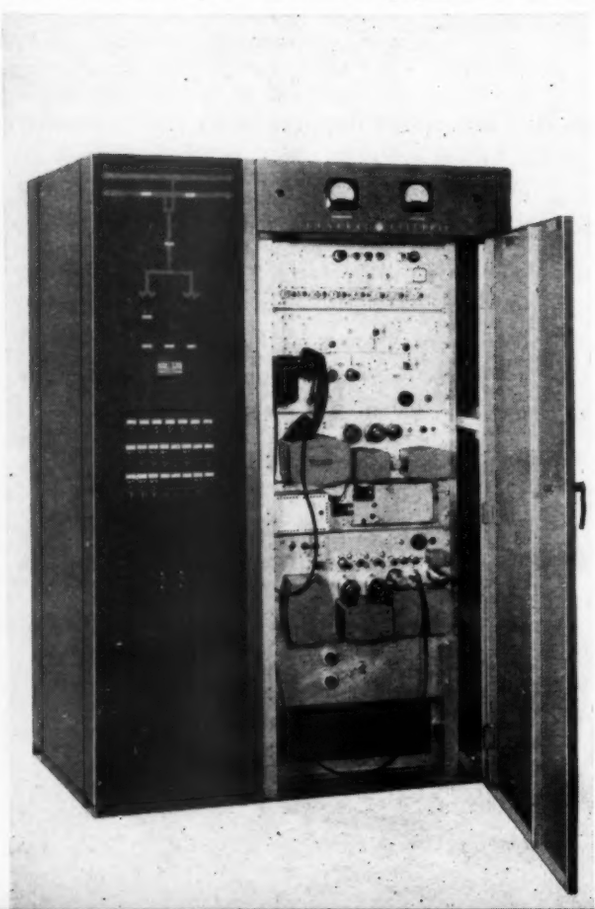
office at station B will require a large number of voice channels. As each of these offices already has a local PAX exchange, all voice channels between them should terminate at these exchanges.

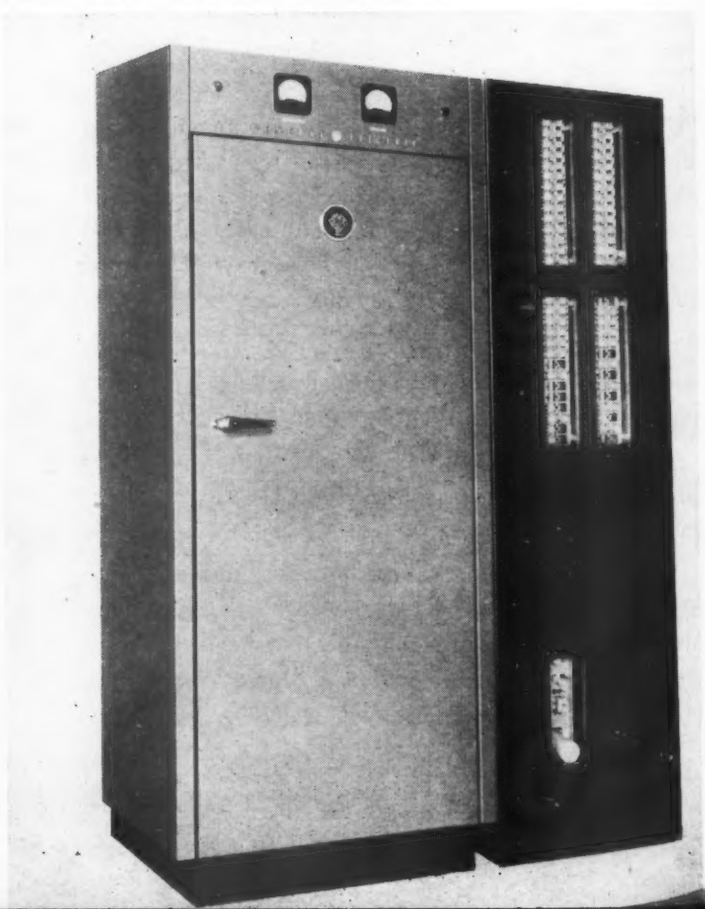
Due to the amount of inter-office communication between these offices, it would take three separate voice channels (channels 1, 2, and 3) to handle this traffic. At station C, however, a small substation midway between these offices, there is no need for these channels and they pass right through this station.

On the other hand, station C is in the jurisdiction of the district office B and therefore it is important to provide a voice channel (channel 4) between these two stations. This channel should also terminate at station B's PAX exchange so that all of the offices are in direct contact with station C.

Like most power utility or pipe line systems, there is a central dispatcher who oversees the entire operation of this system. The dispatcher is located

FIG. 7-AB. Local station microwave equipment for use in remote and supervisory control operations.





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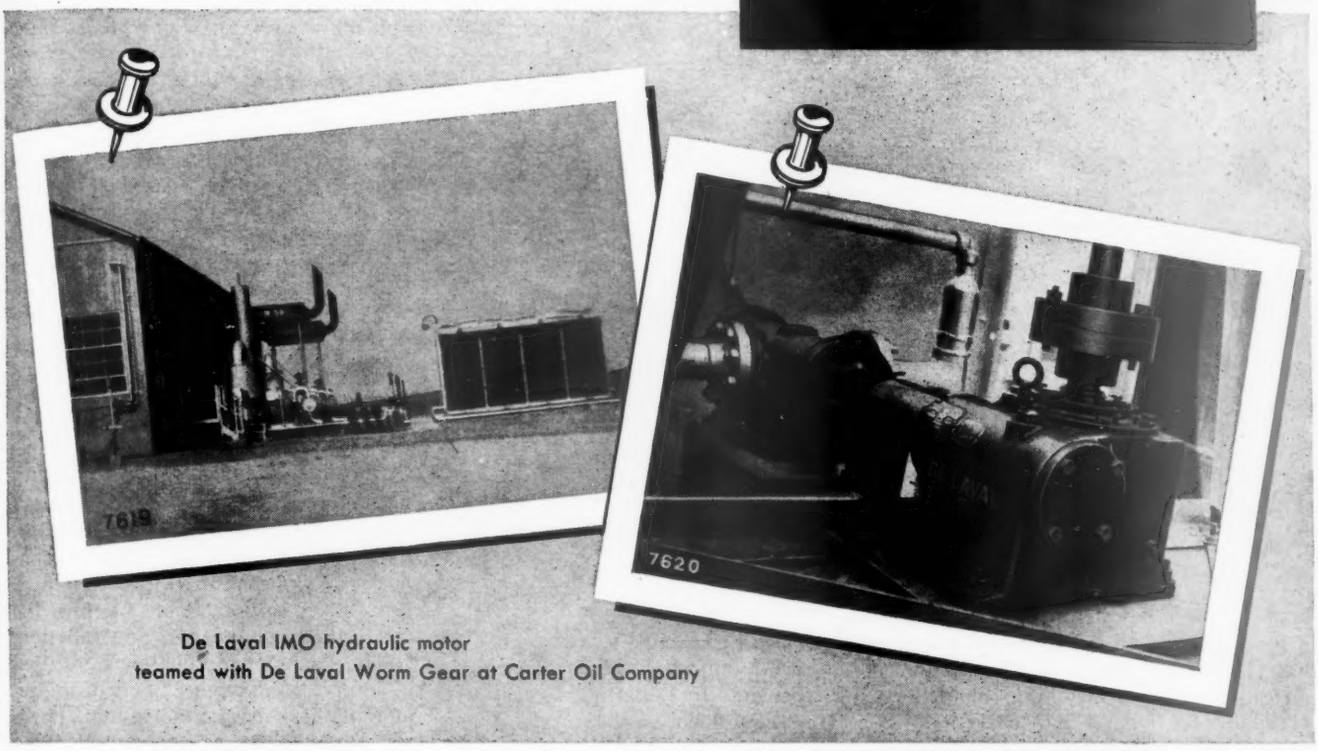
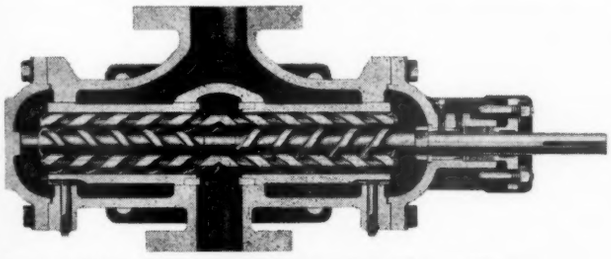
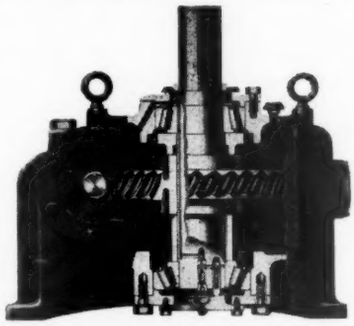


De Laval IMO hydraulic motor
teamed with De Laval Worm Gear at Carter Oil Company



De Laval IMO A324A hydraulic motor. Capacities to 200 gpm; temperatures to 250 F; pressures to 500 psig.



De Laval Type WVC Worm Gear; 5 to 75 hp; ratios 3⅝:1 to 11⅔:1; center distance 4.00" to 13.50".

De Laval IMO hydraulic motors and pumps have operated twenty-four hours a day for over two years on the Happy Cooling Tower at the Carter Oil Company, Elmore City, Oklahoma Compressor Station.

Fans are driven through De Laval WVC Worm Gear Reducers. There is absolutely no vibration or noise. The equipment has yet to require maintenance of any consequence. Indications point to a long, trouble-free life expectancy.

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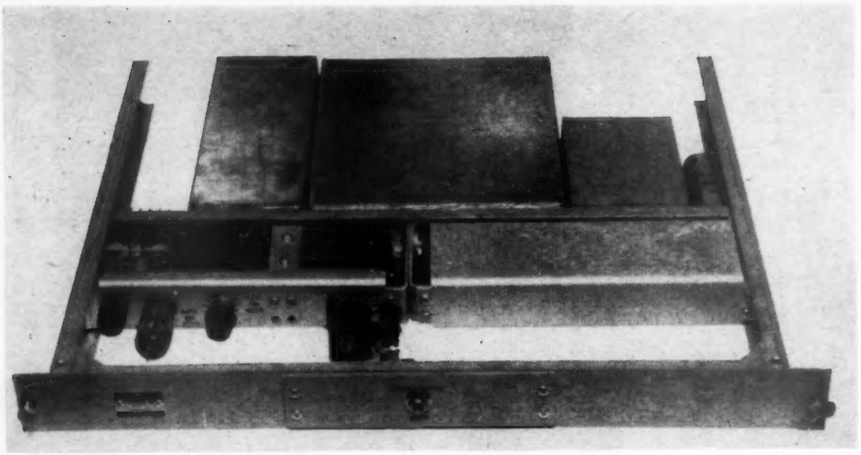

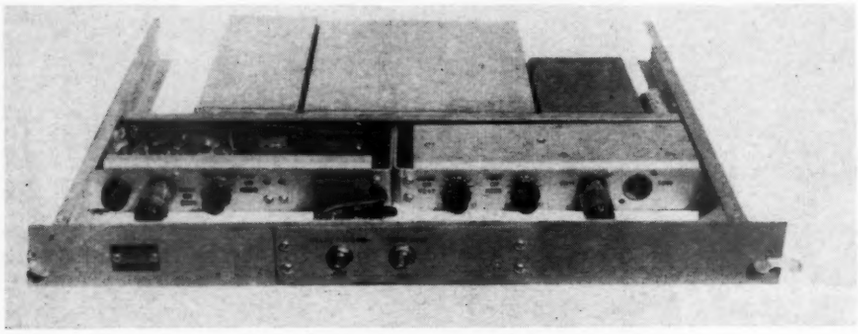

FIG. 8. A—Top photo, tone transmitter. B—Above, tone receiver.

at station A and all stations must have direct communication with this point. Operation of the dispatching channels is usually on a party line basis with either code ringing or selective tone calling between stations. Therefore, Channel 6 will provide communication between the dispatching offices at stations A, B, and C.

Telemetering and Supervisory Control

In addition to voice communication between various stations, provision must be made for telemetering and supervisory control (Figs. 6 and 7). Transferring these control and indicating functions require one voice channel for approximately 10 to 15 functions, together with one tone channel for each function. In the case of telemetering functions, it is a one way tone channel, whereas supervisory control is fundamentally a two way system.

To provide these functions between station C and station A, an additional channel must be added. As channel 4 does not go beyond station C, it can be used to provide the station C to station A channel thereby allowing more room for future expansion.

Tone Equipment

At station C, an audio tone generator is installed to transmit the output of the telemetering equipment over this channel to station A, where a tone receiver will transfer information back in a form used to trigger the telemetering receiver.

Tone equipment (Fig. 8), operating at a different audio frequency, will provide the supervisory control function at these stations. The tone signal going out from station A will indicate the function to be performed, and signal coming back will indicate that the function has been performed.

Tone equipment can also be used for telegraph circuits, protective relaying circuits, and other control functions. In each case, however, type of tone and speed of the tone channel may vary in accordance with application. The exact number of tone channels that can be accommodated on one audio voice communication channel depends upon the spacing that can be used. For tone channels having fast response time, spacing and band width used will be greater and therefore a smaller number of channels can be accommodated. Fig. 9 illustrates the required spacing for some typical functions.

FIG. 9. Spacing of tone channels.

Function	Spacing 10 cycles
TELEGRAPH (slow)	120
TELEGRAPH (high)	360
TELEMETERING	120
DIALING	120
SUPERVISORY CONTROL	360
RELAYING	1800

VHF Units Included

As mobile VHF units are normally dispatched from main headquarters, provision should be included so that the remote base stations can be controlled from the central office. This central control is extremely important and if the area to be covered is large there will be many remote stations in use to cover the operating area of a power utility or pipe line.

In the typical case considered here, the remote station is located at station B while control is desired from station A. One voice communication channel (channel 5) will be used for this purpose. Since personnel at station C sometimes have need to dispatch or talk with the mobiles, facilities are provided so that they too may have remote control of the VHF station.

Use of General Channels

In addition to providing the actual voice channel for this use, a control function must also be incorporated that will key the base station transmitter each time the operator depresses his push-to-talk button. In most equipment this function is available by rewiring the ordinary channel ringing function.

The same general channels are used to complete the requirements of the remaining branches of the system. There are, however, a few variations on the stations A to F section that deserve discussion.

At station D, microwave channel 8 is terminated and the audio passed directly to the power line carrier channel. The patch is accomplished so that all functions are continuous.

The VHF channel 5 for the stations A to F section has the control at station A and the VHF base stations at stations D and F. Because of the interaction that would be experienced if both of these base stations are actuated at the same time, it was considered necessary to add to this channel, selective tone equipment with which the operator at station A can choose the base station desired and transmit on either or both as required.

Party Line Channels

Channel 4 in the stations A to F section is a party line channel terminating at stations D, E, and F. It also carries two telemetering channels from each of these stations to station A. These tones working with 6 to 27 cycle frequency type telemetering instruments require only 120 cycles of the audio band width and therefore there is sufficient space still available in a 3000 cycle channel for approximately 12 additional telemetering channels.

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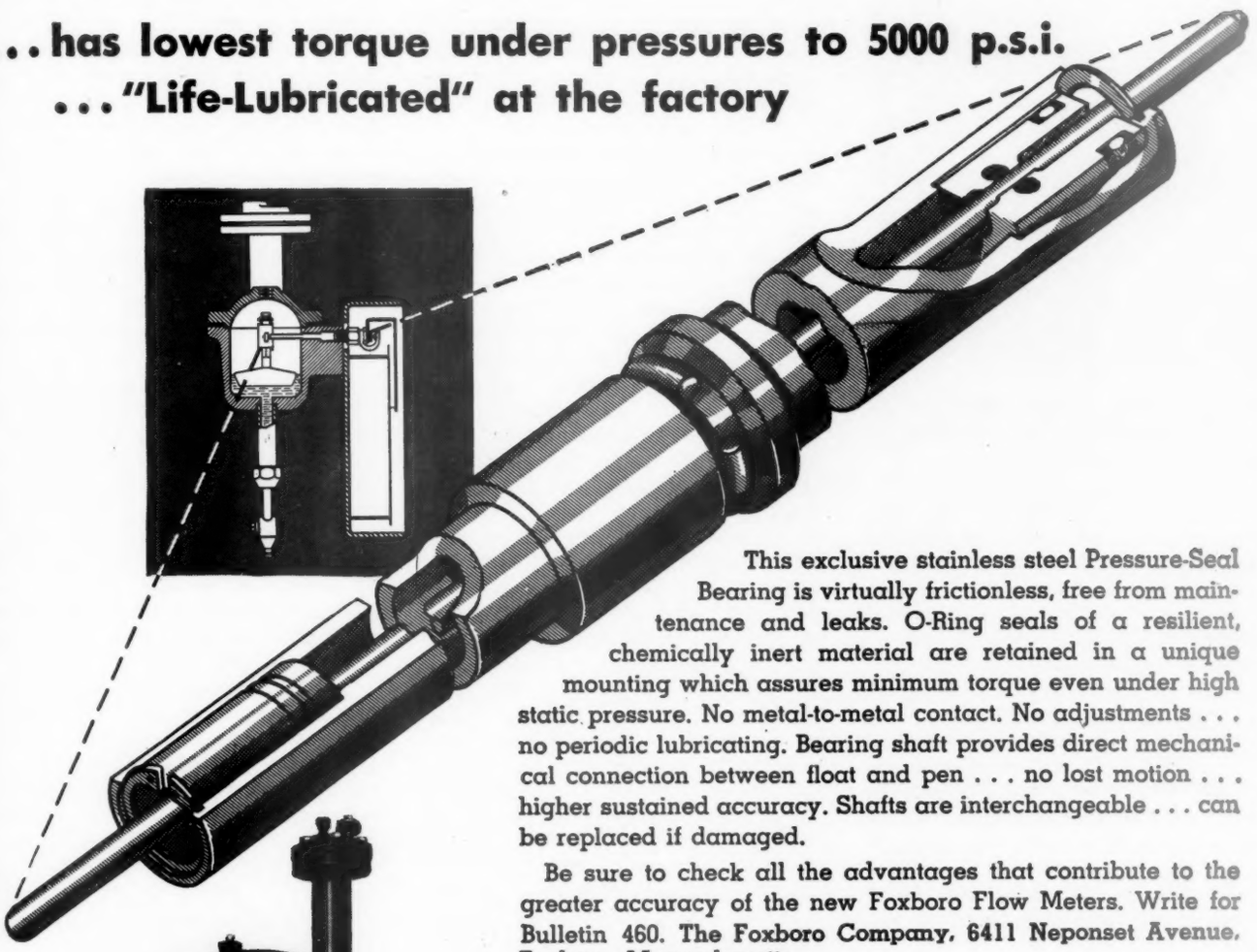

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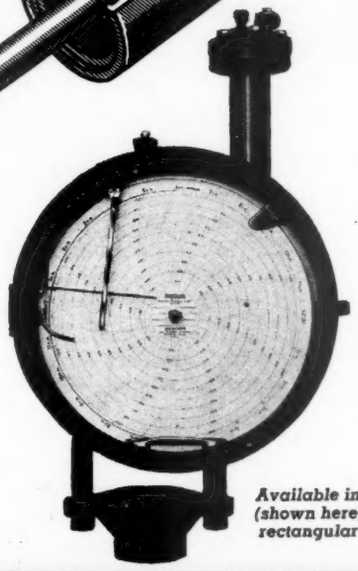

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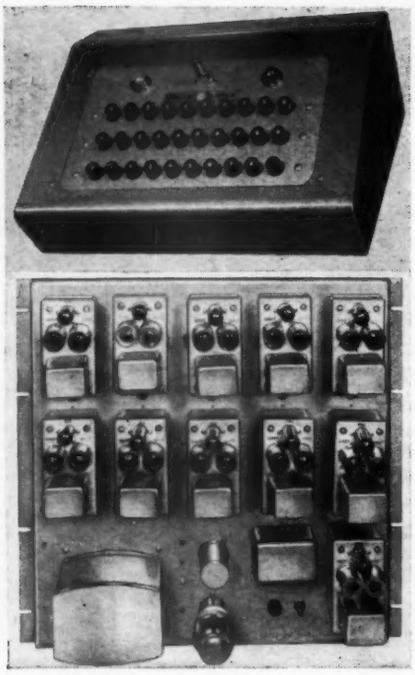


FIG. 10. Tone selective calling, showing control unit and the tone generator and power supply unit.

Channels 6 and 7 of the same section are party line channels available at at each station. For channels of this nature there are three types of calling that can be specified and the final decision depends upon the exact use of these channels. The least expensive solution would be application of 20 cycle or 60 cycle code ringing. Such a solution, however, has the disadvantage in that it may be annoying to the personnel located at these stations as they must continuously listen to all signaling on this channel. If channels are used to any great extent and signaling is almost continuous, this could become extremely annoying.

Selective Calling

Under these conditions it would be beneficial to apply selective calling in one of its two forms: The first involves the application of the selective tone unit at each station (Fig. 10). With this system, each station is assigned a specific tone frequency and the phone at the station will ring only when this frequency is applied to the microwave channel. Obviously, this is an excellent solution when there is only a limited number of stations operating from the same microwave channel.

If the number becomes too great, each station would require a tremendous number of tone generators in order to originate the desired frequency from the called station. Number of tones needed could be reduced tremendously if two-tone calling were employed as the available combinations rise quite rapidly.

To obtain a system of calling more in line with standard telephone practices, yet still keep the cost within reason, a simple dial unit has been developed that will provide the second method of selective calling to those channels (Fig. 11). This unit, incorporating standard dial stepping switches, will permit use of a standard dial telephone at each station and permit dial signalling between stations.

In addition, the unit will provide lock out either during dialing or during entire conversations. This feature assures accuracy of dialing and also permits conversion of an ordinary party line circuit into a private line to assure uninterrupted conversations. To round out its operation, this unit also provides busy signals, and ring back tones for supervision of the circuit.

Varied Applications

There are, of course, many applications for microwave channels that have not been discussed in this part of this proposed system. Each organization may have an application slightly different from any of those discussed. It must be remembered that microwave systems, as they are now marketed, are extremely versatile and are so constructed and engineered that they may be applied to almost any application.

Their construction is such that by the application of the correct terminating units and accessories, the voice channels may be made to provide almost any special service. Herein lies the work of the application engineer and success of the final system depends on correct application of various units available to him.

In reviewing the channel requirements for our typical system for the station B to F section, good engineering and application practice dictates that either the 2000 mc or 7000 mc equipment be utilized.

Station E to station G, however, offers the opportunity of applying low cost 960 mc equipment since the present and future requirements for voice channels are low and the system is a spur from the main communications circuit.

Before considering the propagation and location of stations there are two additional channels that must be considered. These channels deal exclusively with maintenance and repair of the microwave system itself. In order to assure maximum reliability, it is considered good practice to have one channel reserved as the microwave service channel and that it be made available at each station for the exclusive use of the radio service men.

In order that these maintenance men are continually informed concerning the operation of the various remote stations, it is advisable that a fault reporting system be incorporated that will report to some central location any irregular operation. Usually this system is designed to report the following items.

1 — Transfer from primary RF units to standby RF units
2 — Operation of primary power
3 — Operation of standby power units and transfer to this unit from regular primary power
4 — Top tower lights
5 — Side tower lights

Is is a requirement of the FCC and CAA that the tower light regulations be observed and failure reported to local responsible people. If tower lights cannot be observed locally, then a system of remote reporting is necessary. It is helpful and economical to report items 1, 2, and 3. The maintenance crew will then know the condition of each station and plan its maintenance trips accordingly. Usually the fault system does not require a voice channel, it is sent by other means. The system will report the stations reporting and the fault that has occurred. * * *

Part 3 of this series will appear in the July Issue.

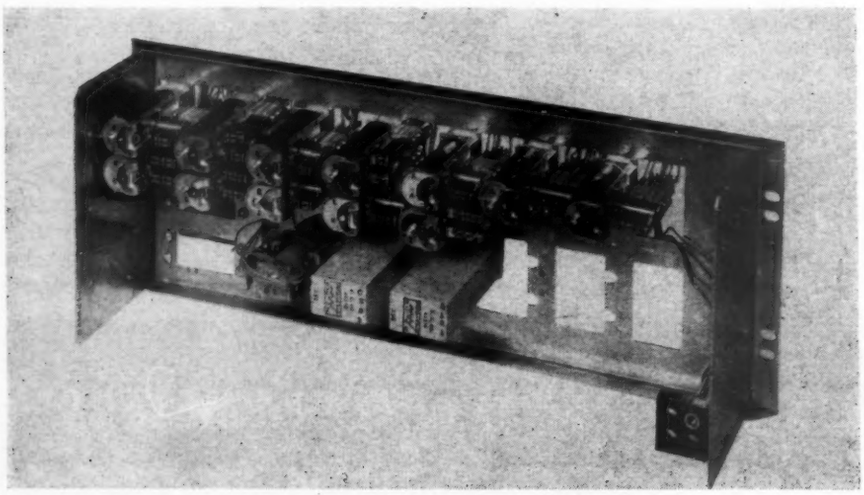


FIG. 11. Dial selective calling unit, front view, cover removed.

Hydrostatic Testing Gas Transmission Lines*

Part 1: Problems, Planning, and Costs

J. S. POWELL and N. K. SENATOROFF

THERE is a great deal of discussion of hydrostatic testing of pipelines in the natural gas pipe line industry. Much is due to the recent large scale use of this type of testing by two large pipe line companies and to the study given to the industry's testing practices by ASA B31-1 Subcommittee 8 on Gas Transmission and Distribution Piping.

Hydrostatic testing of gas piping facilities is not a new practice. It has been used extensively by some companies for 20 years or more and to a very limited extent by almost all companies operating high-pressure gas facilities.

At present, the most widely used testing procedure in the natural gas transmission industry is to fill the new facility with natural gas to a pressure 50 psi higher than the maximum working pressure and check for leaks or other defects disclosed by this pressure. If the facility successfully passes this test, the pressure is dropped 50 psi to the maximum operating pressure and it is ready to go into operation.

Compared with this test procedure, hydrostatic testing under even the most favorable conditions is a relatively complex and costly procedure. Under unfavorable conditions resulting from lack of planning, lack of experience, or adverse weather or mountainous terrain, the operation can become very costly and bothersome. Most of the industry's reaction to this type of testing is based on cases of this type.

It is not the purpose of this article to discuss the relative merits of the industry's present gas testing practice and hydrostatic testing. The proponents of hydrostatic testing claim two advantages for it:

1. The test itself is safe.
2. Failure of lines during operation is less likely if hydrostatic testing is used, because of the high test pressures that can be employed safely during a hydrostatic test.

It is fairly obvious to everyone that greater safety can be achieved by hydrostatic testing, consequently it is currently a matter of importance to the industry to know just how important the problems connected with hydrostatic testing are. It is the purpose here to study these problems and to point out practical solutions, where such exist, and to point out conditions under which hydrostatic testing should not be attempted.

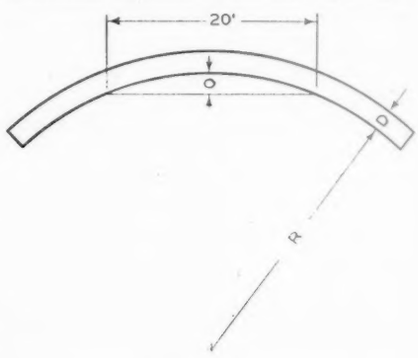
In brief, hydrostatic testing is conducted in this manner:

After a section of the line is completed, water is pumped in at one end to displace the air by forcing ahead of it a plunger with rubber sealing cups called a "pig" or scraper. The filling of the line is accomplished rapidly by the use of a high capacity fill pump. A high pressure, lower capacity pump is then employed to increase the pressure to the specified test pressure which can be much higher than the maximum working pressure.

The pressure is maintained for a specified period; any leakage of water from the line is indicated by a drop in pressure and the size of the leak by the pumping rate required to hold the test pressure. Leaks or "blowouts" in the line are then found by patrolling the right of way and observing wet spots or washouts in the backfill. When the point of failure has been found and repaired, the line is again pressurized. After all the weak spots found have been repaired, the water is displaced from the test section by gas or air forcing a second "pig" through the line.

Planning the Hydrostatic Test

Frequently, testing of a pipe line is not considered as a part of the pipe line construction project and is not adequately planned for. To prevent delay in putting the line into service it is essential to schedule the testing of sections of line as they are ready, rather



DIA. "D"	RADIUS "R"	MIDDLE ORDINATE "O"
16"	48"	12.5"
18"	54"	11.0"
20"	60"	10.0"
22"	66"	9.0"
24"	72"	8.5"
26"	78"	8.0"
30"	90"	6.5"
32"	96"	6.0"
34"	102"	5.5"
36"	108"	5.0"

FIG. 1. Recommended radii for pipe bends for most effective pig running.

*Presented at Pacific Coast Gas Association, Spring Meeting, 1954.

The Authors

J. S. Powell N. K. Senatoroff

J. S. Powell is asistant research engineer with Southern California Gas. He was graduated from the University of California in 1937 and is a registered chemical engineer in the state of California. He has been with his present company since 1938 in various capacities in the technical department and is at present supervising the chemical, gas measurement, and engineering labs.

N. K. Senatoroff is chemical engineer for the Southern Counties Gas Company. He is a 1928 graduate of California Institute of Technology.

His industry affiliations have been with all four gas utilities in the Los Angeles area. Los Angeles Gas and Electric, Southern California Gas, and finally, with Southern Counties Gas Company and Pacific Lighting Gas and Supply Company. During this term of association, he has served the gas industry in the following capacities: Chemist, research engineer, and his present position since 1941.

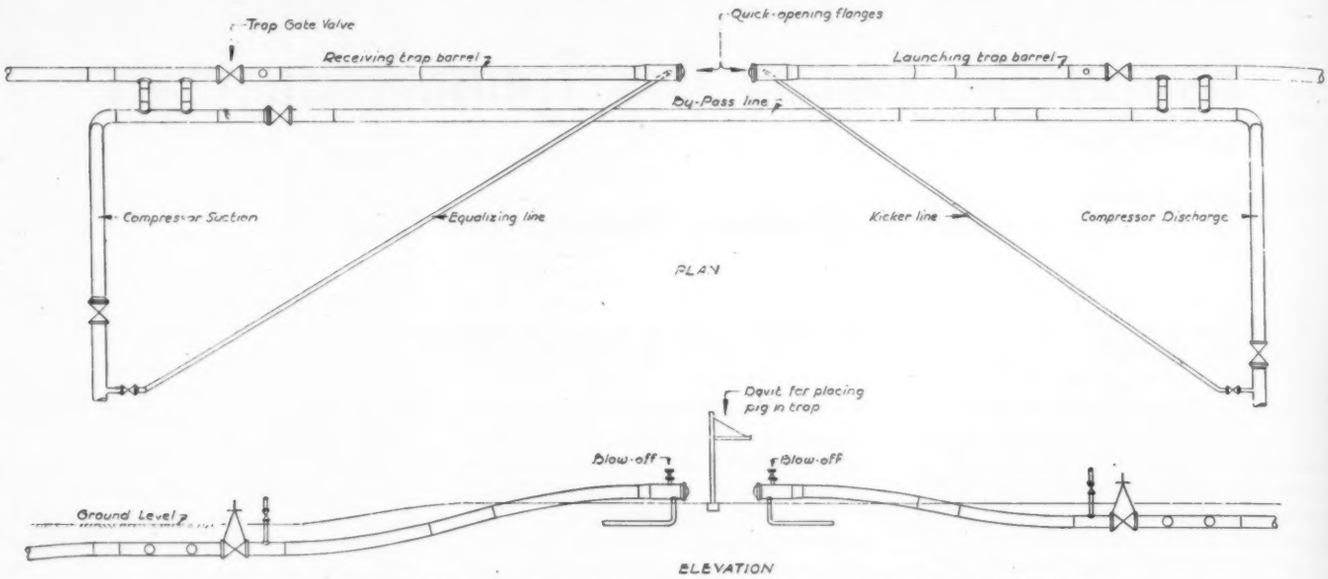


FIG. 2. Permanent pig trap at compressor stations for on stream "pigging" of the line.

than when the entire project is completed. In order to do this it may be necessary to start a pipe line spread at a source of water for the tests.

In addition, to prevent difficulties and delays and to minimize costs of hydrostatic testing, attention should be given during the design and planning stages of the pipe line project, to such details as location of vent valves, availability of water for the test, and sizing of the filling and pressurizing pumps. Consideration of these details emphasizes the need for advance planning to assure smooth and economical execution of the project.

Several obvious advantages will result from such advance planning. It will enable the designer to foresee the financial needs related to the cost of special pipe line features needed for the test. It will permit forecasting the organization personnel requirements for efficiently conducting the hydrostatic test. It will provide the opportunity of weighing the relative merits of company versus contractor performing the test. In brief, it will substitute a carefully planned and "on schedule" type of activity for the "fire fighting" type frequently observed where the hydrostatic test is conducted as an afterthought.

The following features should be considered in the design of a pipe line to be hydrostatically tested:

Minimum radii for pipe bends and welding ells. If the conventional type of pipe line pig is to be used to remove or move the water, it is recommended for the most effective water removal and to prevent a pig from becoming stuck in the line, that the pipe line design specify pipe bends with a radius curvature of at least seven pipe diameters (Fig. 1). If this is not possible welding ells of not more than 22½ deg with a radius of 1½ pipe diameters are suggested.

Successful pig running, however, has been reported in pipe lines with 10 deg miters and 90 deg ells with a radius of 1½ pipe diameters. In such instances the pig design should be checked in order to verify its usability and efficiency for water removal.

Variation in pipe diameter. Successful transfer of water from one section of the line into another, or the removal of it after hydrostatic testing, depends to a considerable degree on the uniformity of the pipeline diameter. Small changes in diameter due to a difference in wall thickness are not objectionable. Obviously, however, the indiscriminate use of different pipe diameter sections, in which discontinuity of pipe sizes might interfere with the passage of the pig, should be avoided.

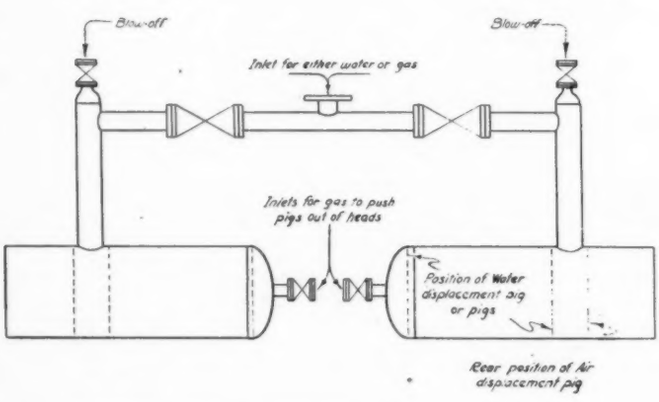

Blow-off
Blow-off
Inlet for either water or gas
Inlets for gas to push pigs out of heads
Position of Water displacement pig or pigs
Rear position of Air displacement pig

FIG. 3. Launching heads and manifold for filling two test sections.

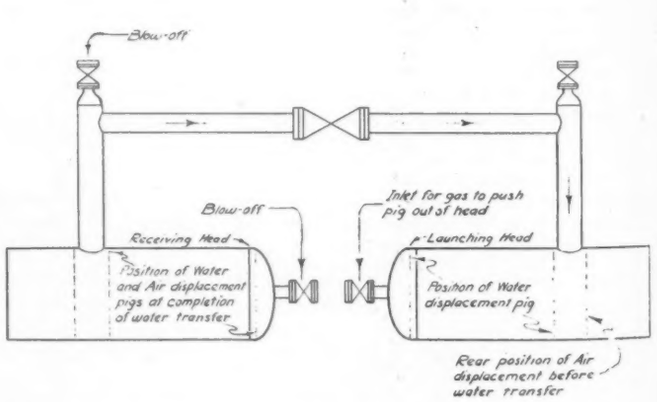

Blow-off
Blow-off
Receiving Head
Inlet for gas to push pig out of head
Launching Head
Position of Water and Air displacement pigs at completion of water transfer
Position of Water displacement pig
Rear position of Air displacement before water transfer

FIG. 4. Launching and receiving heads with manifold for water transfer from one test section to another.

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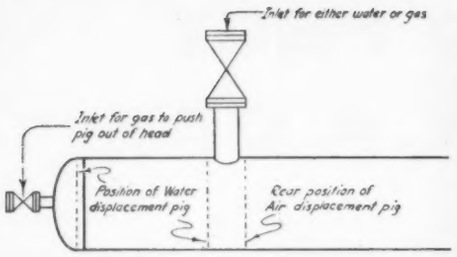

Inlet for either water or gas
Inlet for gas to push pig out of head
Position of Water displacement pig
Rear position of Air displacement pig

FIG. 5. Launching head equipped for filling of one test section only.

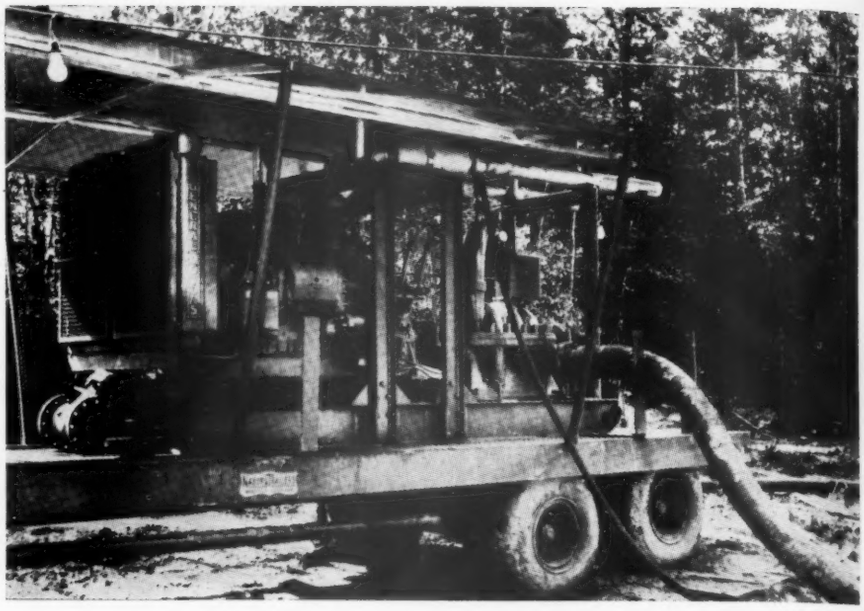
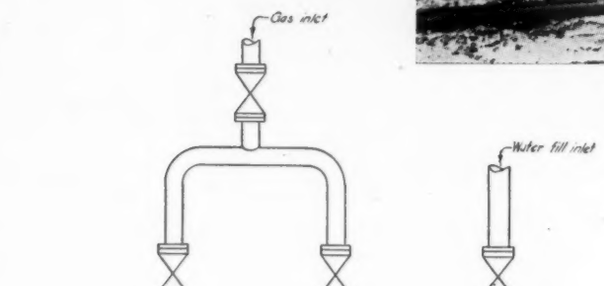


FIG. 7. Heavy portable fill pump 1000 gpm at 350 psi (2100 gpm at 200 psi — normal operation).

FIG. 6. Multiple pig launching head and manifold.


Gas inlet
Water fill inlet
Position of N°3 water removal pig
Position of N°2 water removal pig
Position of N°1 water removal pig
Inlet for gas to push pig out of head
Water fill and drain taps
Rear position of Air displacement pig

Abrupt changes in size form pockets in the line which assist in collection of water in places from which removal is difficult.

Size and type of valves and fittings. For all practical purposes, selection and sizing of valves and fittings also follow the line of "least resistance." Namely, the use of full opening block valves is preferred to the extent permissible by other design considerations. If the full opening valves are not provided the sectionalizing of the line for testing must be between the mainline valves, unless these valves are installed after the test is completed.

Pig traps. In the past, in planning natural gas transmission line installations, most of the designers provided only temporary facilities for the pig launching and receiving operations. Use of the pig was primarily intended for either cleaning the lines of construction dirt and water, or of dust which was formed later on and accumulated due to the internal corrosion which was taking place in the lines handling gas which had not been dehydrated.

In order to maintain maximum efficiency, many of the new lines in the planning or construction stage are including facilities for the "on-stream" running of pigs as a permanent feature of the line itself.* Such facilities are are very useful after a hydrostatic test and tend to reduce the cost of such a test in the case where several pig runs are contemplated.

Obviously, no one single design of pig trap will give the most universal service for every pipe line. As a rule, however, most of the users of pipe line pig traps report that the horizontal type is preferred to the vertical for both the suction and discharge piping of compressor plants.

The traps consist of: A receiving and launching section of the pipe (the so-called trap barrels), mounted as shown in Fig 2 with davits, quick-opening flanges, trap gate valves, by-pass and blowdown lines, and the "kicker" line for dispatch of the pig.

The special temporary fittings and equipment that are considered essential for ease and convenience in hydrostatic testing are:

Manifolds and launching and receiving heads. Four designs are shown in Figs. 3, 4, 5 and 6. Fig. 3 shows the arrangement for filling two sections in opposite directions; Fig. 4, the means for transferring water being displaced from one section after test into another section for test; Fig. 5, the arrangement for filling at one end of a section only, and Fig. 6, a launching manifold and head for separately running several pigs.

Pigs. The latest type of pipe line pigs are designed to "flow through" most of the properly sized and installed fittings and full opening valves. Many different types of pigs are currently available.

Pumps for filling the line. After selection of the locations for water supply, the question arises of selection of pumps which would be capable of not only filling the line with desired dispatch but also providing ample lift to meet the static heads encountered in the elevated parts of the pipe line right of way.

In Fig. 7 is shown one of the typical filling pumps mounted on a truck, thus made easily transportable. It is a 3-stage, 6-in. centrifugal pump, of 1000 gpm capacity against 350 psi static head, or 1200 gpm capacity against 200 psi. The engine shown is a twin diesel capable of delivering continuously 185 bhp.

In Fig. 8 is shown a high pressure pump. It is a 3-stage, triplex power pump, single-acting, with 3-in. plungers, pumping 95 gpm at 140 strokes per minute with a maximum pressure rating of 5000 psi. It is mounted on a diesel truck and powered by the truck engine. Also supplied is a 500-gal tank with a 2-in. centrifugal pump to fill it and 40 ft of 2000-lb test steel hose.

In sizing the fittings and connecting

*See paper on the "Economics of Internal Cleaning Gas Lines During Operation" by E. T. Robinson, Jr., *The Petroleum Engineer*, D-19, October, 1953.

FIG. 8. Pressure pump — truck operating 95 gpm. Maximum rating 5000 psi.

lines for water filling purposes, it is important to have them large enough to handle the needed volumes of water or gas without causing undue pressure drops. From past experience of some of the pipe line companies, it was learned that sizing of equipment for only the expected average rate of filling is not adequate. Some allowance in capacity must be made for peak rates of filling requirements.

In some cases, the recommended oversizing of equipment approached the 35 per cent figure in excess of the estimated size, based on the average rate, and has proved satisfactory at times of unexpected emergencies such as approach of bad weather, breakdown of other equipment, etc. In the case of sizing gas connections, ample excess capacity should be provided to overcome serious leakage past a stuck pig and thus build up the required differential to get the pig past the obstruction.

To estimate the quantity of water required for a test and to determine the time required to fill the test section of the line, refer to Table 1.

Water supply and disposal sources. A survel of available source of water along the right of way of the line is very important both from the standpoint of capacity and quality and should be made before construction planning is undertaken. The right of way should also be surveyed for means of water disposal after the hydrostatic test.

The selection of the most convenient site of water supply is also important for the coordination of the hydrostatic testing with the general construction schedule. No less important is the location of water disposal site. Some states require that the water, after the test, shall be returned to the stream from which it was initially pumped out.

These two requirements, of water supply and disposal, appear on the face as very difficult objectives to achieve in some instances. There are reported cases, however, in which the limited water supply problem was economically handled by re-use of the water in several sections of the line simply by transferring it with proper tie-ins of manifold sections of the line for tens, or even hundreds, of miles from the initial source of supply. In such cases, adequate filling pump capacities and coordination of construction and testing scheduling made the completion of the job possible without delay.

Elevation profile. It is important for the engineer in charge of hydrostatic testing to have a detailed profile of the line, because in crossing mountainous country it might be necessary to very carefully sectionalize the line in order to subject all parts of the test section to an adequate pressure without overstressing the low end of the line because of the water head and to select adequate equipment to handle filling and pressurizing of the line.

Altimeter readings along the right of way should be used by the engineer to plot the expected static pressures against the footage scale in order to provide quick estimates of water volume required to fill the line to any point. The plot should also indicate exact locations of block valves, welding ells, pipe bends, pig traps, water sources and water disposal facilities. With all of this information readily available, the engineer in charge is in a position to determine the best way of sectionalizing the line for hydrostatic testing and deciding on the best sequence for testing the sections.

Services available. The pipe line company may obtain all of the above described testing facilities and to the hydrostatic testing with its own personnel. However, in the long run, unless the company expects to have enough testing work to keep such facilities and personnel busy a large part of the time, it might be cheaper to contract the testing and have it directed by a company engineer. At present there is one concern that will provide and operate all of the facilities necessary for testing; they also make water and altimeter surveys along the pipe line right of way.

Climatic Conditions for Testing

Hydrostatic testing has been successfully conducted in very cold weather when the atmospheric temperatures have been as low as 5 F below zero; no testing has been done with ground temperatures at pipe depth below freezing, although ground temperatures have been as low as 35 F.

It is the consensus of several companies that have done a good deal of hydrostatic testing that it would not

TABLE 1. Pipe line capacities and filling time per mile versus pipe size for 100 gpm filling rate.

Size O.D.	Capacities—gallons per 1 ft length	Capacities—gallons per mile	Time in Hr/Mile
16″	9.84368	51,971.04	0.87
18″	12.50656	66,033.44	1.09
20″	15.44620	81,554.44	1.36
22″	18.67756	98,616.32	1.64
24″	22.22308	117,331.28	1.96
26″	26.06032	137,594.60	2.29
28″	30.20424	159,473.60	2.65
30″	34.63240	182,856.08	3.04

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E-180 - 54

be feasible to hydrostatically test a pipeline with a ground temperature below 32 F.

The use of antifreezes has been considered, but the cost would be prohibitive in most cases. It therefore is concluded that hydrostatic testing should only be done when the ground temperature at pipe depth is above 32 F. Air temperatures below freezing do not create a serious problem; at most it is only necessary to provide some means of heating or protecting the piping above ground through which the water is pumped or discharged. Freezing air temperatures usually precede freezing ground temperatures by a month or more and in most cold parts of the United States it is not until December or January that freezing ground temperatures at pipe depth occur.

If only a portion of the length of a proposed pipe line is located in areas where freezing ground temperatures might be encountered, the construction schedule can usually be arranged so that these sections of the line are constructed and hydrostatically tested during seasons when freezing ground temperatures do not exist.

Cost of Hydrostatic Testing

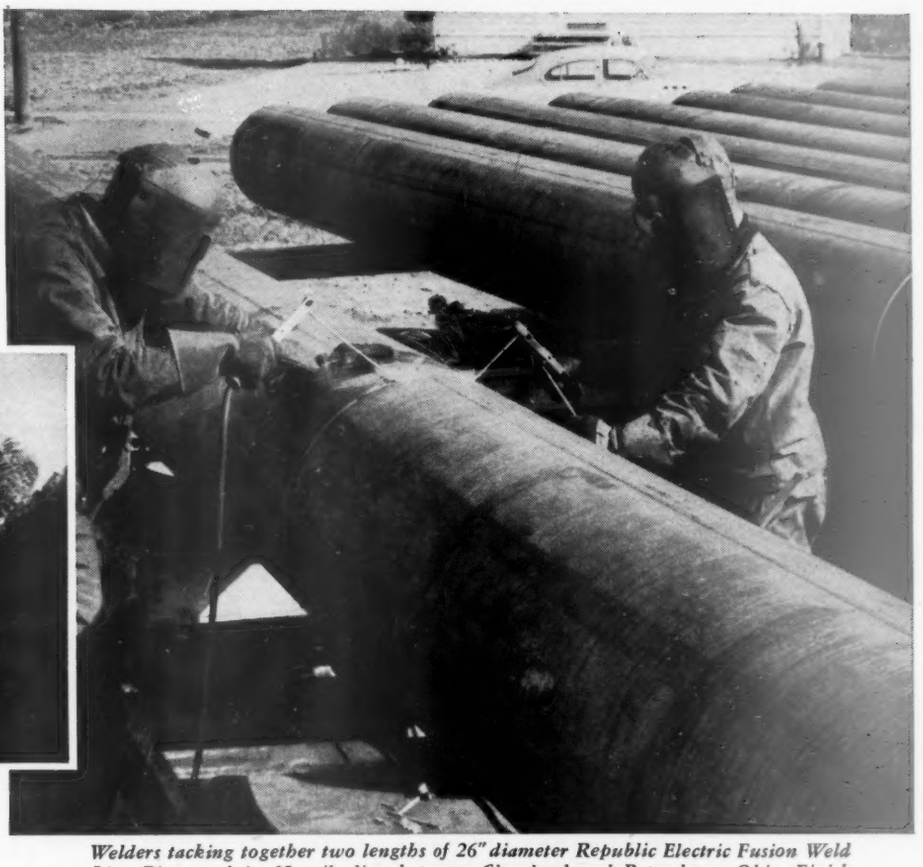
The cost of hydrostatic testing will vary considerably depending mainly upon the length of line and the adequacy of the equipment used in testing. Costs have been reported by some companies of from 10 to 50 cents per foot for large diameter pipe lines. It is obvious that for a short length of line the cost will be high on the per foot basis because a large part of the cost is getting prepared for the test which is not proportionately more for a long line.

Inadequate equipment and failure to design the pipe line so that it can be easily tested are very important factors in making the cost of hydrostatic testing high. Too often fill pumps with low capacities and discharge pressures are used and filling of the test section takes an unreasonably long time without filling it sufficiently so that the high pressure pumps can rapidly complete the filling to the test pressure.

The argument is offered that hydrostatic testing delays completion of the line, and the loss of revenue makes the cost of testing high. It is believed that by adequately planning the testing as part of the pipe line construction as described previously that there will be no significant delay and, in fact, in many cases less delay will be encountered than if a gas test were made. * * *

Part 2 of this article, which will appear in the July issue, will discuss procedures used in hydrostatic testing.

Crews find that the uniformity of Republic Electric Resistance Weld Pipe makes for rapid welding.



Welders tacking together two lengths of 26" diameter Republic Electric Fusion Weld Line Pipe used in 65 mile line between Cleveland and Petersburg, Ohio. Finish welding will be done on a Fusion Weld field unit.

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Republic Electric Fusion Weld Line Pipe comes in sizes 24" through 30" O.D. Republic Electric Resistance Weld Line Pipe runs from 2⅜" through 16" O.D.; Republic Continuous Butt Weld Pipe from ⅛" through 4" nominal.

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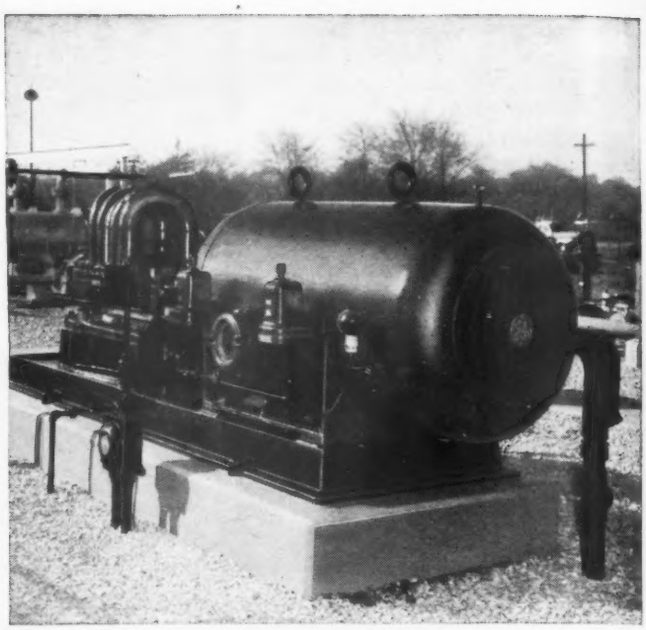
To obtain more information on products advertised see page E-61

XUM

TRI-CLAD* VERTICAL explosion-proof motors, like these belonging to Pan American Pipe Line Company and located adjacent to Rancho Pipe Line System's Eldorado Station, are available to suit the requirements of the pump mounting. This is just one of G-E's complete line of pipe-line motors.



TOTALLY ENCLOSED EXPLOSION-PROOF motors have been tested and listed by Underwriters' Laboratories for Class I Group D hazardous locations. Like this one at Sinclair Pipe Line Company's Clinton Station, they withstand all weather conditions, do not require firewall.

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G.E.'s application and field engineers can serve you as a staff of experts on all your electric pipe-line equipment—to give you a co-ordinated, well-balanced system. And no matter where your pipe line reaches, you'll find G-E sales and service facilities all along its path to help you keep your throughput at a maximum under all conditions.

For more information, contact your G-E Apparatus Sales representative. *General Electric Company, Schenectady, N. Y.* 830-2

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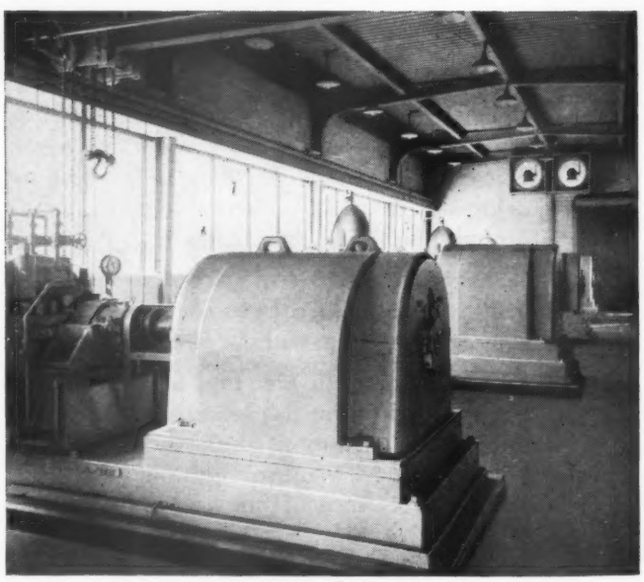
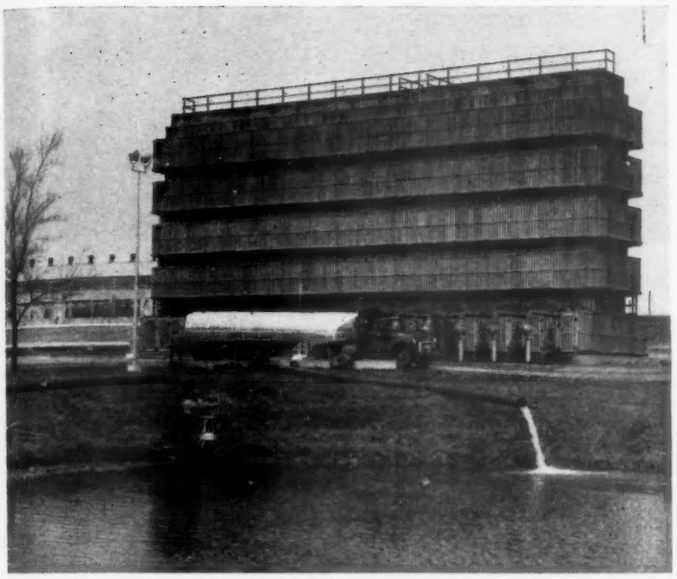
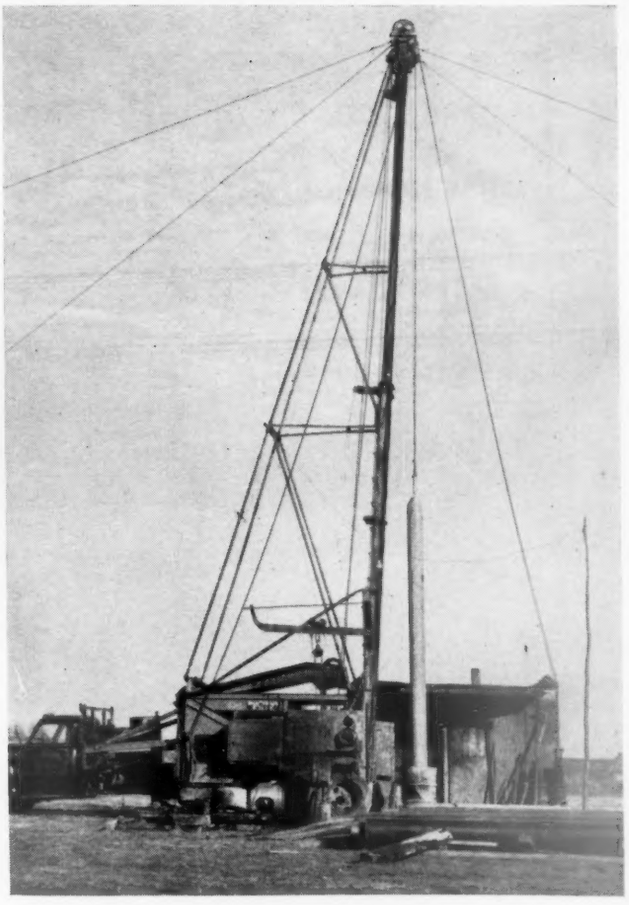


BASE-VENTILATED MOTORS up to 3000 hp may be force-ventilated like these at Rancho Pipe Line System's Garfield Station. Separate blowers are started in advance to purge motor and duct system.

GENERAL ELECTRIC



Water from truck transport being dumped into settling basin at Panhandle Eastern Pipe Line's Louisburg compressor station. The 25-mile water haul from Marais Des Cygnes river was necessitated by Kansas' drought conditions.



Water-well drilling rig in operation on Louisburg station site. This is first of six water-producing wells drilled at station to help alleviate water shortage.

EXCLUSIVE

Obtaining water for Panhandle Eastern's Louisburg station cooling tower no ordinary problem; extended Kansas drought prompted

"OPERATION WATER HAUL"

R. A. VAN LEUVAN*

RECENT substantial rains brought to a halt — at least temporarily — one of the most unusual operations carried on by Panhandle Eastern Pipe Line company during its existence, a waterhauling project at the Louisburg compressor station south of Kansas City.

"Operation Water Haul," necessitated by a precipitation deficiency of 14.33 in. in the Louisburg area in 1953, got under way in December, 1953, of last year and continued through this spring. During that period 4000-gal capacity trailers working around the clock hauling in approximately 9,450,000 gal of water from the Marais Des Cygnes River, 25 miles from the station, to fulfill Louisburg's daily requirements of 80,000 gal.

Water recovered from April showers is being stored in Louisburg Lake No. 2, constructed in 1952. The second lake was built with the intention of using it on a standby basis in case of emergency. It has a surface area of 4.65 acres and a capacity of 37,975,608 gal. Hot weather and the rainfall deficiency hastened the drying up of the original lake in 1953.

Compressor department officials estimated that approximately 3,525,000 gal of water were recovered following rainfalls in April. Late in April water in the second lake stood at 9,150,000 gal.

The water hauling operation, which company officials feel need not be resumed if precipitation figures in the area return to normal, commenced only after consideration was given to several other methods of obtaining water for operational use at the station. A permanent water pipe line and hauling in water by rail were ruled out in favor of the truck hauling project. Also considered as a means of conserving water was the construction of a closed water system at the station.

Six water wells drilled on the station site have helped to alleviate the water shortage. The wells are providing 39,000 gal per day, about 40 per cent of the station's daily requirements. * *

*Panhandle Eastern Pipe Line Company, Kansas City, Missouri.

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30 DIGGING FEEDS up to 18 feet per min.

and 6 speeds on digging wheel (up to 11.2 r.p.m.) give you maximum trench production at every width, depth and in all soil conditions with this Parsons 215 Trenchliner. Heavy-duty digging wheel cuts 13 to 31 inches wide, in depths up to 6 feet. Square or round-bottom buckets are equipped with easy-in-easy-out "Tap-In" teeth. They're inserted in less than a minute, self-sharpening, interchangeable to any bucket or side-cutter position. Digging wheel holds accurate grade, responds instantly to friction clutch control. Clutch also acts as an automatic safety — protects against shock loads.

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You'll like the way this 215 cross-country Trenchliner fits right in with other equipment in your pipeline spread. It has *standard* tractor crawlers, with 18-inch treads and lug-type shoes. Choice of 2 *standard-make* 55 h.p. diesel engines simplifies operation and maintenance programs. See Parsons distributor, or write us.

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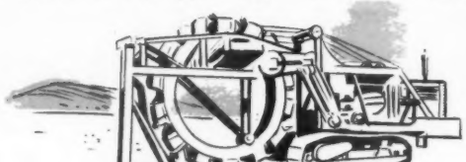
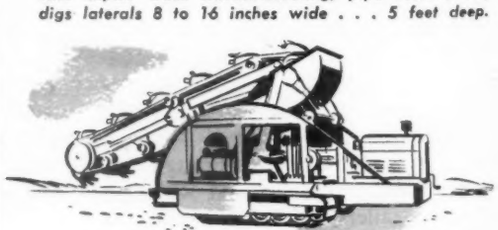
Other sizes, types dig 8 to 72 in. wide:



Parsons wheel-type 202 Trenchliner, for utility and drainage work, has 16 or 20-inch rail-type crawler treads . . . digs 13 to 31 inches wide, 6 feet deep.

Rubber-tired 88 Trenchmobile® drives anywhere at 12.6 m.p.h. Does trouble-shooting, pipe reclamation, digs laterals 8 to 16 inches wide . . . 5 feet deep.



3 large sizes of Parsons ladder-type Trenchliners, full-crawler mounted, give maximum cutting widths of 36, 42 and 72 inches, depending on model . . . and maximum digging depths of 8½, 12½, and 17 feet.

Map of Platte Pipe Line system. New stations at Holdrege and Gower are marked with stars. They will help boost capacity to 143,000 bbl per day.

RUSH ORDER!

Two New Platte Stations Near Completion

Many advanced design features incorporated into Platte Pipe Line's new Holdrege and Gower stations; buildings are latest in architectural trend, functional throughout

MELVIN M. LEE*

A new chapter is being added to the story of the Platte Pipe Line, by the addition of two main line pump stations needed to meet steadily increasing transportation requirements.

Late in 1952, Platte began transporting the crude oils of Wyoming, Nebraska, and Colorado to the refineries in the East. Since then, crude oil receipts each month have exceeded the preceding month. The line had been in operation barely eight months, when a throughput of 100,000 bbl per day was reached and plans were announced to supplement capacity by the addition of two new pump stations.

Originally, the new stations were scheduled for mid-summer completion; however, tenders of oil traffic rose so rapidly that in March it was not possible to transport all the oil that was tendered. Consequently, the two stations, located near Holdrege, Nebraska and Gower, Missouri, are being rused to completion. They will help speed to market the oils from the new prolific fields of the Denver-Julesburg Basin. Upon completion, the present maximum capacity of 110,000 bbl daily will be augmented by 33,000 bbl per day.

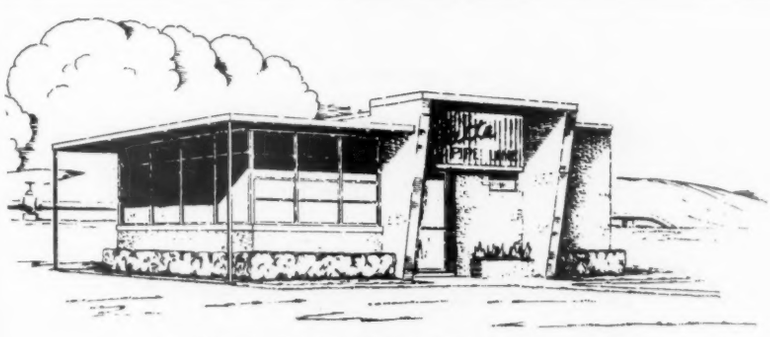
The higher capacity will be only in that part of the line between Gurley, Nebraska, (where Platte receives Julesburg Basin oil from three pipe lines — The Ohio Oil Company, Pure Transportation Company, and the Sterling Pipe Line System) and Salisbury, Missouri, where Platte delivers to Sinclair Pipe Line Company's new big-inch line to Chicago. West of Gurley and east of Salisbury, Platte's capacity is presently adequate to handle foreseeable traffic.

Advanced Design Incorporated

Station piping for the new stations is simplified to the bare essentials of pumping in series through any combination of as many of the four centrifugal pumps, as desired. The first pump is capable of producing 100 psi with a 350-hp motor, while each of the other three units can increase the pressure by 300 psi, utilizing 900-hp motors.

*Design engineer, Platte Pipe Line Company, Kansas City, Missouri.

EXCLUSIVE



Architect's drawing of one of the two new stations.

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Peak performance, maximum efficiency, greater output, and lower power costs can be built into your oldest, and of course your newest, compressors by the installation of VOSS VALVES.

Check **THESE VOSS VALVE ADVANTAGES:**

✓ Quiet, vibration-free operation ✓ 20 to 60% more valve area ✓ less power consumption ✓ minimum pressure loss ✓ normal discharge temperature ✓ lower operating costs ✓ utmost safety

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The motors for these units are to be 2300 v, 750-rpm, explosion proof electric motors with Class B insulation.

In each instance, the local power company will extend a 34,500 v line to the station site, where a complete substation will be erected to provide power. Electricity has been adapted to nearly all of the needs for power, controls, instrumentation, and heating. The pumps and valves are to be operated by electric motors. The controls and instruments are actuated by electronic impulse. This is a variance from the control system previously used by Platte, where the instrumentation was based on hydraulic pressures rather than electrical impulses.

Functional Buildings

Another departure from past Platte practices is in connection with the pump and control buildings. Through a study of comparative costs of materials and construction methods, it was possible to develop designs in keeping with the latest architectural trends and still effect savings. These buildings, while keeping their same functional make-up, will take on new dress with larger window areas and modern pylons of Roman brick. From the industrial type doors and windows of the past, they will take a step toward the residential style. The exterior of the buildings will be of mat faced red brick, trimmed with cut stone, while the interior will be of ceramic glazed tile. Acoustical tile ceilings will be used throughout.

The ideas of many operators have been incorporated into the design of these buildings to make them more convenient, safe, easier to maintain, and a more pleasant place to work. The buildings are heated by electric convectors and electric baseboard heating panels.

The existing microwave system will transmit the station pressures to the dispatcher's board in the Kansas City office and carry the dispatcher's signal for remotely operating pumps and valves.

Construction of these stations was begun in December 1953, and will be completed in June 1954. The need being so urgent, each pump will be put into service as soon as it can be installed and the building will be constructed around them.

Two operators will be situated at each station. Cottages are being built on the site to house the men and their families. * * *

With a capacity of more than 5,500,000 bbl, the pipe line and attendant tank farms of the "biggest inch" pipe line, in Texas, could hold all the oil produced there in two days.

LESS LABOR KILLS more brush at lower costs when you use "Ammate." It kills more kinds of brush than most weed and brush killers and keeps brush down longer!

AFTER THREE YEARS—Here's the same right-of-way as shown at left. Brush still remains under control, yet low-growing natural cover returned to resist erosion.

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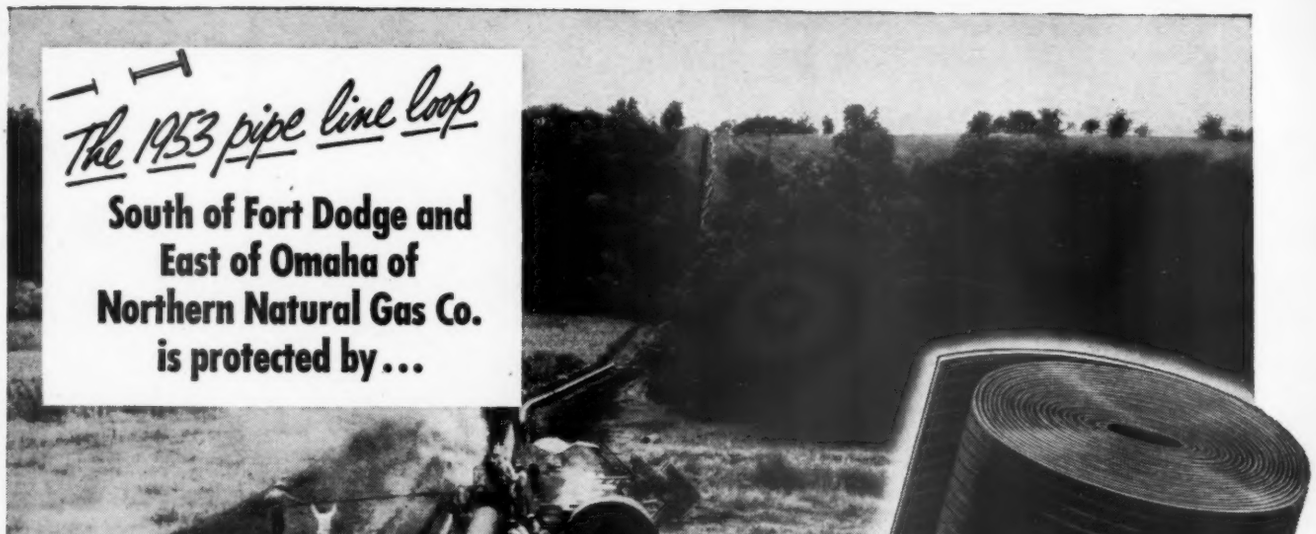
On all chemicals always follow directions for application. Where warning or caution statements on use of the product are given, read them carefully.

EVEN WHERE right-of-ways adjoin sensitive crops, like cotton, you can rely on "Ammate" to do the job safely. That's because it's not volatile—reducing spray-drift damage to a minimum.

MAINTENANCE CREWS and custom sprayers prefer "Ammate" for faster, safer, longer-lasting control of brush. And they can use it without hazard to themselves, livestock or wildlife. "Ammate" is non-flammable, too.



The new pipe line of the Northern Natural Gas Co., consisting of 70.8 miles of 30" pipe, extends the firm's natural gas service into central Iowa.

New lightweight, reinforced TRANSHIELD ASBESTOS PIPE LINE FELT

Permits high speed wrapping... assures effective protection for enamels

TRANSHIELD now offers pipe line men the fine protective qualities of an asbestos shield at a lower price ... with the added advantage of improved application characteristics. Transhield is a quality felt ... assuring long trouble-free service. It is designed to meet all ordinary wrapping needs.

Transhield provides a continuous asbestos membrane, protecting and preserving the enamel coating. Highly resistant to soil stress, it is particularly suitable for use where pipe must be laid in heavy clay soils. It cannot rot or decay... presents an almost indestructible barrier against soil chemicals.

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Adsorption of Monoethanolamine From Natural Gas

Results of tests made at Denver Research Institute prove value of activated bauxite bed for removal of DEG and MEA concentrations

THOMAS D. NEVENS

THE ever increasing use of high pressure natural gas lines and the continuously increasing initial and maintenance costs of these lines has greatly stimulated use of diethylene glycol and monoethanolamine as scrubbing materials to remove water vapor and acid gases that would otherwise condense from the gas to form hydrates and corrode and plug the pipe lines.

The use of the diethylene glycol and monoethanolamine treatment, has however, introduced the additional problem of removing the small quantities of diethylene glycol and monothanolamine which are vaporized into the natural gas, so that they too will not condense in the pipe line.

In an effort to determine a practical method to remove the diethylene glycol (DEG), and monoethanolamine (MEA) from natural gas, and further, to obtain data for design of a plant to remove these constituents, a study sponsored by the Stearns-Roger Manufacturing Company was carried out by the Denver Research Institute, University of Denver, to determine the absorption capacity of an activated bauxite bed for the two materials.

The Author

Thomas D. Nevens has been a research engineer in the chemistry and chemical engineering division of the Denver Research Institute, University of Denver, for the last four years. During this time he has done industrial research in the fields of vapor-liquid equilibrium relationships, heat transfer, and mass transfer. He is a chemical engineering graduate from the University of Colorado, and obtained his PhD at Ohio State University.

Description of Apparatus

Major components of the experimental equipment were a blower, saturating column, air heater, activated bauxite adsorption column, steam superheater, and MEA - DEG - H_2O solution storage tanks. The arrangement and purpose of the components of the equipment may best be described by following the gas and liquid streams through their respective circuits.

As shown in Fig. 1, the 75 per cent diethylene glycol-20 per cent monoethanolamine-5 per cent water solution (hereafter referred to as MEA solution) was stored in a 55-gal tank and was fed by gravity to the saturator. Such a solution is frequently used for the double purpose of extracting water-vapor and the acid gases, carbon dioxide, and hydrogen sulfide, which often are found in natural gas.

The MEA solution entered the top transition section of the saturating column through a pipe which extended down 18 in. into the 4-in. by 4-ft steel pipe column. The top 18-in. section of the column was packed with ¾-in raschig rings, which served as an entrainment separator, while the lower 30-in. section of the column that served as a saturator was packed with ⅜-in. raschig rings.

From the packed section of the column, the MEA solution flowed into the bottom transition section, which served as an air seal, and a bucket from where it was pumped to the storage tank. In order to control the temperature of the MEA solution, the storage tank was provided with coils immersed in the solution through which either hot or cold water was passed.

A high pressure blower connected to the bottom transition section of the saturating column was provided to force the air through the packing where it was saturated with the MEA solution. The saturated air left the column through the top transition section and passed to a 3-ft long concentric pipe

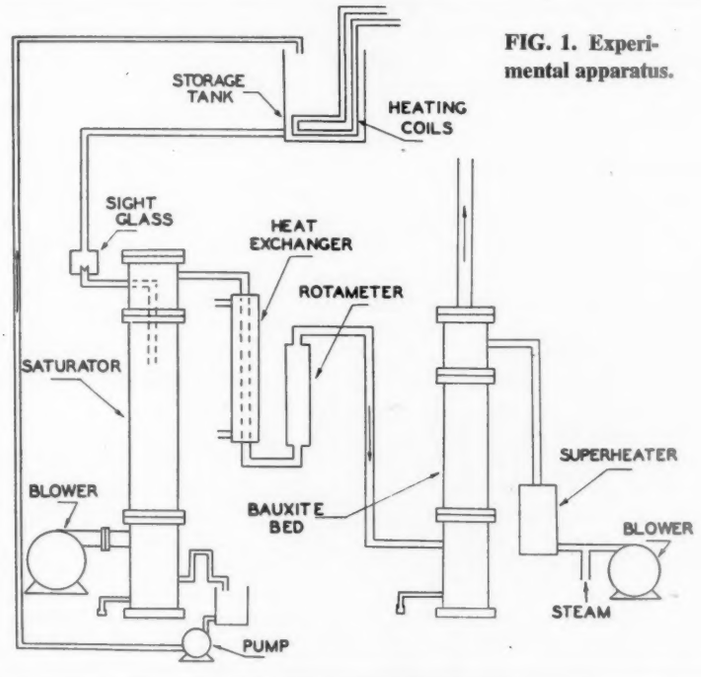

FIG. 1. Experimental apparatus.

EXCLUSIVE

heat exchanger with hot water, through a rotameter, and then a 2-in. gate valve used to control the air flow rate.

Air entered the bottom transition section of the adsorption column, passed up through the 4 to 8-mesh activated bauxite bed and out of the top transition section and was exhausted to the atmosphere. The bauxite bed was contained in a 4-in. diameter by 2-ft high steel pipe column and supported on a 16-mesh screen.

Regeneration Apparatus

The apparatus used for regenerating the bauxite bed consisted of a side-arm water heater and a blower. Saturated steam at 60 psig was passed through the side-arm heater and was superheated to approximately 500 F. It then entered the top transition section of the bauxite adsorption column and was discharged from the bottom transition section. Following the steam regeneration, air was heated to approximately 500 F and blown through the column to dry the bauxite bed.

To avoid excessive corrosion from the MEA solution, all materials in contact with the solution or the vapor were steel. No copper alloys could be used. In order to reduce heat losses from the equipment, all piping between and including the air heat exchanger and the adsorption column was insulated with 1-in. glass fiber.

Temperatures of the MEA solution entering and leaving the saturating column and of the air at the inlet to the rotameter were measured with thermometers inserted in the respective lines. The temperatures in the bauxite bed were measured with thermocouples imbedded in the center of the bed at 6-in. intervals. One thermocouple was also installed in the space just above the bed to determine the temperature of the air leaving the bed and the temperature of the steam and air for regeneration.

Experimental Procedure

In order to determine with a minimum of experimental data the effect of bed depth and contact time upon the adsorption capacity of a bauxite bed for monoethanolamine, eight runs were made at atmospheric pressure through two different bed depths (12 and 24-in.) and at two different air flow rates (70 and 25 ft per minute).

The operating procedure followed in making a run consisted of turning on the MEA solution pump and adjusting the solution rate through the saturating column to approximately 120 lb per hour. The hot water to the heating coils in the storage tank was turned on and the solution heated to the desired temperature and held constant throughout any one run. At the same time, the hot water to the air-liquid heat exchanger was turned on and adjusted to approximately 120 F.

After the MEA solution had been adjusted to the desired temperature, the blower to the saturater was turned on and the air rate adjusted to the desired value and kept constant throughout any one run. The temperature of the air entering the bauxite bed was periodically adjusted by controlling the temperature of the water to the air-liquid heat exchanger so that the temperature of the bauxite bed was maintained at 100 F.

In order to maintain the bauxite bed at 100 F, it was necessary to heat the air leaving the saturator to a temperature of approximately 120 F to counterbalance the heat losses from the rotameter, pipe, and bauxite bed. Heating the air to a temperature above the temperature of the saturator also insured against condensation of the MEA in the lines between the saturator and the bauxite bed.

The concentration of monoethanolamine in the air entering and leaving the bauxite bed was determined hourly by a titrimetric method, which consisted of bubbling a known volume (4-8 cu ft of air through a Fisher-Milligan bubbler containing 250 ml of dilute HCl (approximately 0.01 normal).

The volume of air sample was measured by passing it through a wet test meter connected to a vacuum line, and the amount of MEA absorbed in the 250-ml sample was determined by titrating a 25-ml portion of the sample with standardized NaOH solution using bromcresol purple indicator.

As the difference between the wet and dry bulb temperatures of the air entering and leaving the bauxite bed was too large to permit the use of ordinary psychrometric methods to accurately determine the water concentration, a gravimetric method employing "U" tubes filled with Drierite was used. As the Drierite absorbed MEA as well as water, it was necessary to subtract the amount of MEA per volume of sample taken for the water measurement from the weight gain of the Drierite.

After the completion of each run, the bauxite was regenerated with superheated steam at a temperature of 500 F, and dried with air at a temperature of 400 F.

Equilibrium Data Needed

In addition to knowing the adsorption capacity of the bauxite bed for MEA at atmospheric pressure and 100 F, it was necessary to know the vapor-liquid equilibrium relations for MEA at the design pressure of 500 psig and 100 F in order to calculate the quantity of natural gas that could be passed through the bed before the concentration of MEA leaving the bed becomes objectionably high. As no vapor-liquid equilibrium data on MEA was found in the literature, a few experimental determinations were made.

A high pressure, electrically heated autoclave was modified to obtain the needed vapor-liquid equilibrium data. A ¼-in. steel tube connected to a nitrogen cylinder was immersed to the bottom of the 4-¾-in. by 36-in. autoclave containing the 75 per cent DEG-20 per cent MEA-5 per cent water solution, and the nitrogen allowed to bubble through the solution and to become saturated with the MEA.

Another tube leading from the top of the autoclave led to a bleed-off valve and then to a Fisher-Milligan bubbler where the MEA was absorbed. The volume of the nitrogen sample was determined with a wet test meter connected to the bubbler and the quantity of MEA absorbed in the bubbler determined by titration.

The temperature in the autoclave was maintained at 100 F and the pressure maintained at 500 psig by continuously adjusting the valve on the nitrogen tank and the bleed-off valve. Data were also obtained at 80 F and 140 F and at atmospheric pressure in order to obtain "K" curves.

In order to minimize the number of variables in the study and to satisfactorily extrapolate the data from the system of MEA-DEG-H_2O air at atmospheric pressure to a MEA-DEG-H_2O-natural gas system at 500 psig, the concentration of the MEA in the air entering the bauxite bed was maintained at approximately the same concentration as the MEA in natural gas leaving an amine scrubber at 100 F and 500 psig. This, of course, was accomplished in this study by controlling the temperature of the MEA solution entering the saturator to the desired value.

The principal result of the investigation was establishment of the fact that the absorption capacity of an activated bauxite bed for monoethanolamine and diethylene glycol vapors is sufficiently great to effectively reduce the concentration of the two vapors in natural gas to a value where they will not condense out in a pipe line operated at 500-800 psig and normal pipeline temperatures.

It was also concluded that an activated bauxite bed containing MEA and DEG may be repeatedly regenerated with superheated steam at 400-500 F a sufficient number of times for the installation of an adsorption bed to be economical. On the basis of the data obtained in this study four plants have been designed and successfully operated. * * *

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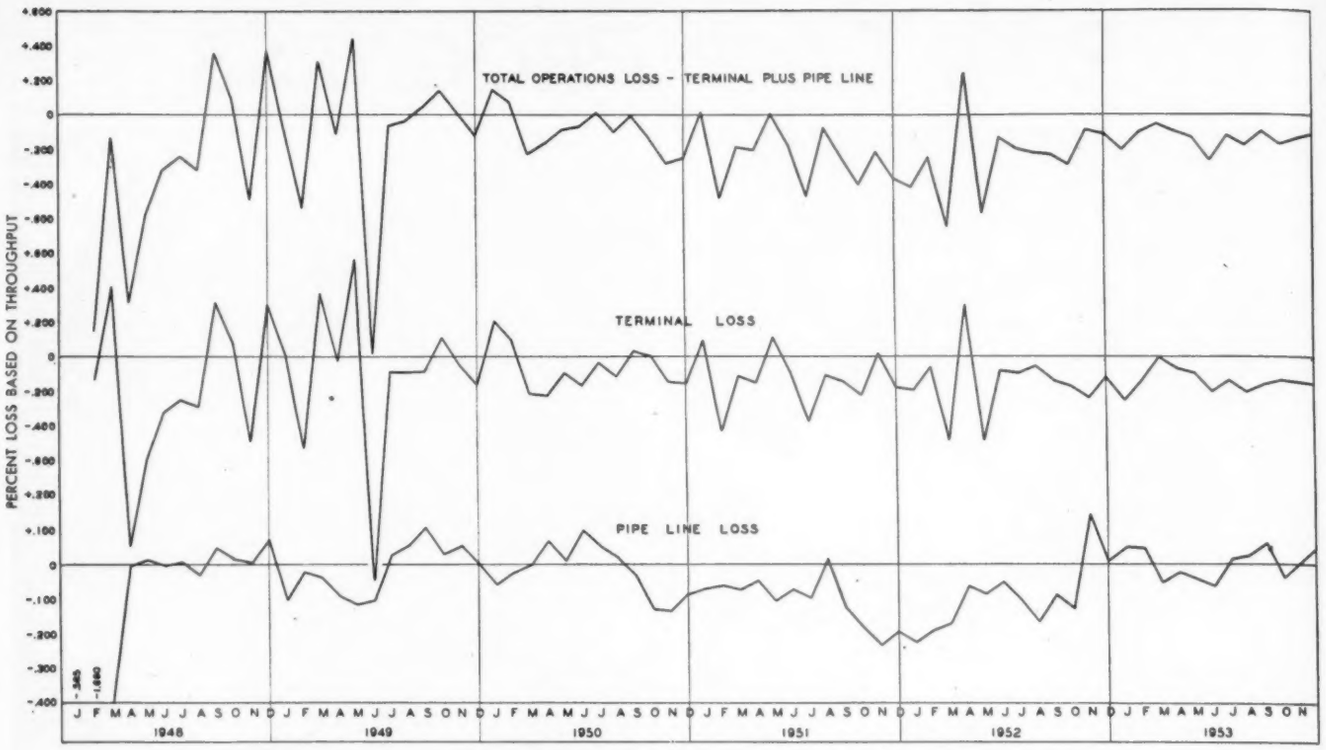
TOTAL OPERATIONS LOSS - TERMINAL PLUS PIPE LINE
TERMINAL LOSS
PIPE LINE LOSS
PERCENT LOSS BASED ON THROUGHPUT
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1948
1949
1950
1951
1952
1953

FIG. 1. Product losses by Wyco Pipe Line Company during six year period of study.

Product Pipe Lines and Terminals: Conservation or Loss . . . Part 2

HOW WYCO REDUCES LOSSES

D. L. RANKIN* and E. H. BAIRD†

THE loss record of Wyco Pipe Line Company covering the first six years of operation is a result of the modern design of facilities that compose the system, the operating methods and techniques developed, and the cooperation of trained employees.

It should be noted that trained and experienced employees normally will remain with a company provided that company has good working conditions, good benefit plans, and wages that are competitive in the industry, and satisfactory management and employee relationships. If these conditions exist, labor turnover will be minimized. Thus, the company will obtain the maximum benefit of trained employees who make a real individual effort to cooperate in a planned training program and follow instructions and techniques that minimize losses.

*Manager, Wyco Pipe Line Company, Denver, Colorado.
†Chief Dispatcher, Wyco Pipe Line Company, Denver, Colorado.

In the May issue of *The Petroleum Engineer* some general observations covering loss problems were discussed, and Wyco Pipe Line Company losses were presented. In this issue, the authors discuss in detail Wyco Pipe Line Company losses. To simplify discussion, Table 1, summarizing Wyco Pipe Line Company annual product losses, and Fig. 1, graphically showing product losses, are again included.

Wyco Pipe Line Company is a common carrier jointly owned by Socony-Vacuum Oil Company, Inc., The Texas Company, and Standard Oil of Indiana. Its function is to transport finished petroleum products from the refineries of the three shippers in Casper, Wyoming, the origin point, to terminals at Cheyenne, Wyoming, and Denver, Colorado, at which points products are loaded into transport trucks, tank cars, or pipe lines as provided in the published tariff rules and regulations.

Wyco's facilities were designed by Service Pipe Line Company and approved by Wyco engineering committee. The Wyco engineering committee was composed of representatives of the three owner companies. With the committee membership composed of representatives with wide experience, the result was a system designed to effect maximum conservation. In fact, all design features discussed in the previous article were incorporated in the Wyco facilities.

Facilities

The facilities consist of 268.5 miles of double-coated and double-wrapped pipe line. The first 7⅓ miles is 6-in., and the balance 8-in. pipe line. The

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pipe line is cathodically protected against external corrosion and protected against internal corrosion by dehydrating all products entering the system. Originating in Casper, Wyoming, the line extends southeasterly to an intermediate terminal at Cheyennne, Wyoming, thence south to the Denver, Colorado, terminal at the end of the line. All volatile products are stored at the terminals in floating roof tanks. All tankage is painted white. The capacity of the system is 24,500 bbl of gasoline per day and requires five stations with a total of 2450 installed horsepower distributed as follows:

Station	Type	Equipment	Horsepower
Casper booster	Unattended	2 motor-driven, semi-automatic operated units	400
Strouds main line	Attended	7 motor-driven units	725
Bear Creek Intermediate	Unattended	3 motor-driven, semi-automatic operated units	800
Bliss Intermediate	Unattended	1 diesel-driven, semi-automatic operated unit	275
Cheyenne Intermediate	Unattended	2 motor-driven, semi-automatic operated units	250

A maintenance crew has its headquarters at Wheatland, Wyoming, approximately midway between Bear Creek and Bliss semi-automatic stations. Aerial patrol service to observe the condition of the line and the right-of-way is provided twice each month on the first and fifteenth.

Fig. 2 is a general map and shows the location of facilities. Fig. 3 is a profile map showing terrain over which the pipe line lies and also the location of main line block valves used to isolate sections of the main line. Fig 4 is an aerial view of the Strouds main pumping station. Fig. 5 is an aerial view of the Denver terminal showing layout, facilities, and the white-painted tanks.

History of Leaks and Losses

Wyco Pipe Line Company completed six years of operation this year. During this period three leaks in the main trunk line and one significant leak in terminal piping were discovered and repaired. All three leaks in the main line were caused by defective pipe not detected during construction. A significant leak occurred in buried terminal piping at a flange joint and was caused by the use of a gasket material that quickly dried out and the fact that half of the bolts in the flange had been left loose. In addition to these actual leaks, an apparent continuous pipe line shortage of product occurred over a two-year period.

After the entire main pipe line passed a satisfactory air test, product was pumped into the line on January 12, 1948. The line was completely filled with product, the first of which arrived at Denver on January 22, but because of a siege of meter difficulties it was impossible to obtain a reliable line balance. By February 1, meter readings indicated a leak of the magnitude of 72 bbl per day. At $5 per barrel, the loss was equivalent to $360 per day.

The line was shut down and pressure tested. The Casper to Cheyenne section tested satisfactorily, but the Cheyenne to Denver section steadily lost pressure. A pressure test was then made simultaneously on all sections of the line between Cheyenne and Denver, and six hours after the beginning of the pressure tests the isolated section in which the leak had occurred was known.

Severe winter weather and 12 to 15 inches of snow covering the ground made locating the leak difficult. This section of the line was maintained under pressure and continually patrolled for 48 hours without success.

Since the line had just begun operation and products had not yet been made available for shippers at terminals, it was decided to resume operations, accept the loss, and continue efforts to locate the leak.

After negative results for two days, during which period the ground remained covered with snow, it was decided to again pressure test the line. The second test confirmed the original area of the leak and located another leak, which was repaired. Continuous patrolling on foot, utilizing available methods of locating leaks, was employed, but with negative results.

Finally, on March 15 a super-sensitive electronic sound amplifier type leak detector was purchased and arrived, and the leak was located on the same day. It was found on the bottom side of the pipe where it lay in porous soil. Repairs were promptly made and the line placed in normal operation. Hourly checks on line balance and batch reports thereafter checked satisfactorily.

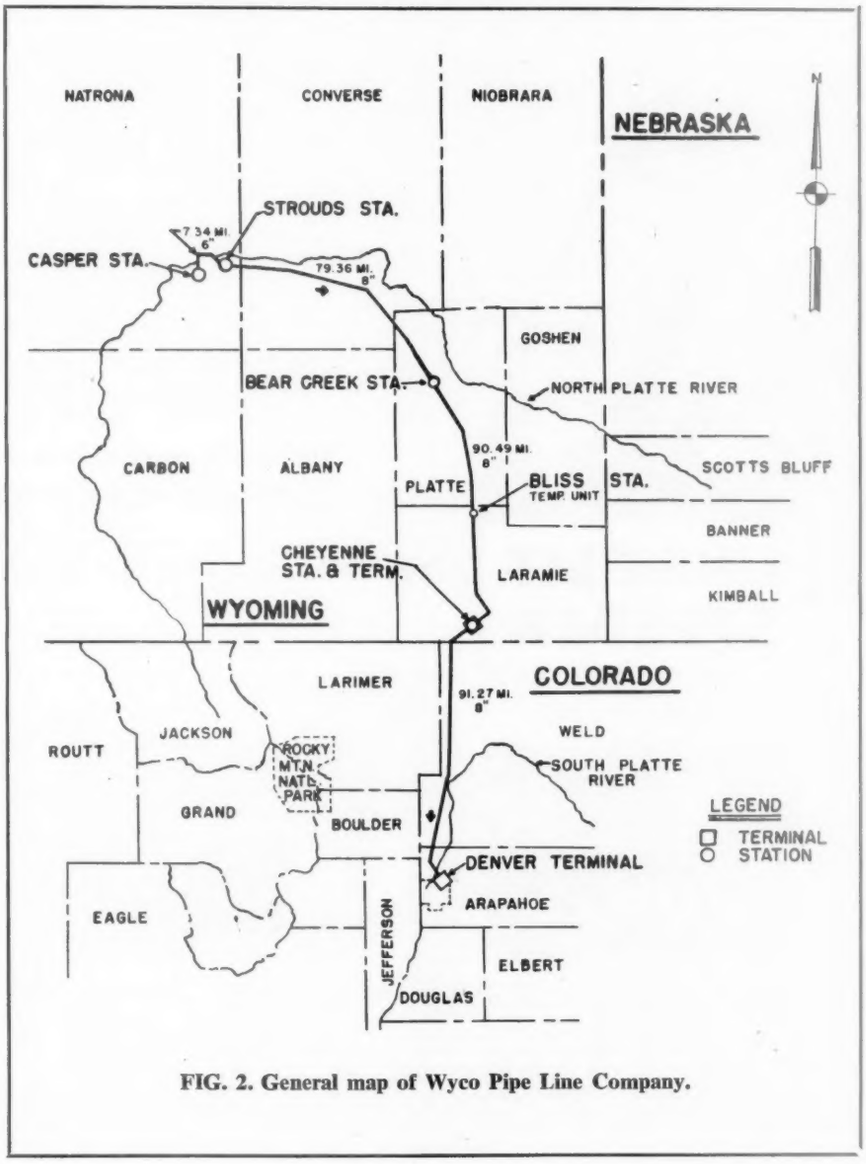

FIG. 2. General map of Wyco Pipe Line Company.

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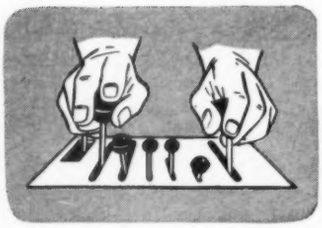

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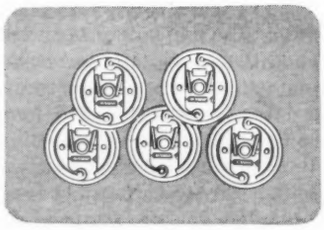

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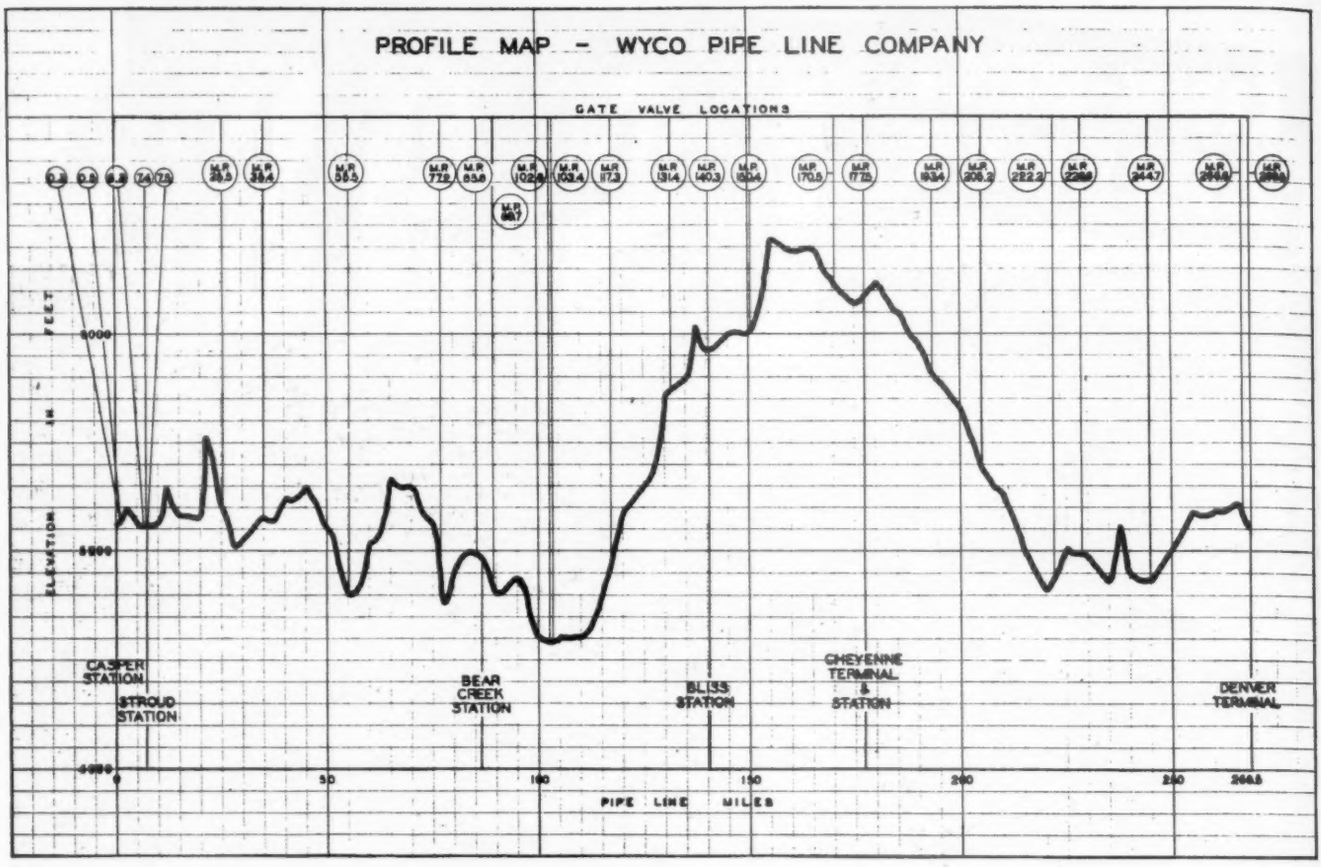

FIG. 3. Profile map of Wyco Pipe Line Company.

The total loss amounted to 5000 bbl during the six-week period while locating the leak.

Third Leak Found

No further pipe line loss difficulty was encountered until October, 1950, when the line again began to consistently show a loss month after month. The line was pressure tested three times during November, 1950, and ultimately the third and last leak was discovered and repaired. This leak was located near the highest elevation point of the line. It is probable that the internal pressure at this location was insufficient to cause the imperfection in the pipe to start leaking until increased operating pressure occurred at this point. Pipe line loss continued excessive, however, from November, 1950, through October, 1952.

During this period, several things were done in an effort to determine the cause of the loss so that preventive steps could be taken.

Ten complete pressure tests were made on the entire main trunk line and all tests showed negative results.

Numerous Studies Made

In addition to conducting the frequent pressure tests on the line, numerous other studies and tests were carried out for periods of at least one full month of operation. The tests were as follows:

1. Comparing volumes obtained from gaging refinery tanks with volumes obtained from station (origin) meters, terminal (destination) meters, and gaging terminal tanks.

2. Comparing volumes obtained from station (origin) meters with volumes obtained from terminal meters, and gaging terminal tanks.

3. Comparing volumes obtained from terminal meters with volumes obtained from gaging terminal tanks.

4. Comparing volumes from Casper station meters with Strouds station meters.

5. Adjusting all products to 60 F temperature basis using API gravity of each individual tender as against group range API gravity as provided in the Wyco tariff. The difference covering one month's operation in corrected volume at 60 F by these two methods was negligible.

None of these test or studies revealed the reason for any pipe line loss. It should be pointed out, however, that these tests clearly indicated that meters were more accurate and more dependable than tank gages.

Extra aerial patrol flights were made at times when losses appeared too excessive, and, in addition, the entire line was covered by line walkers.

Pressure testing of lines and facilities inside the station or terminal headgate block valves was begun in March, 1952, and resulted in finding the one significant leak in station and terminal piping. Again, results of testing station and terminal piping did not eliminate excessive loss.

Under these conditions the possibil-

TABLE 1. Wyco Pipe Line Company product losses.

Year	Average actual annual loss %			Average adjusted annual loss %		
	Pipe line	Terminal	Total	Pipe line	Terminal	Total
1948	—0.168	—0.196	—0.370	—0.011*	—0.102†	—0.114
1949	—0.011	—0.104	—0.103	—0.001	—0.095†	—0.096
1950	—0.023	—0.070	—0.093	—0.023	—0.070	—0.093
1951	—0.101	—0.137	—0.234	—0.101	—0.137	—0.234
1952	—0.094	—0.147	—0.242	—0.094	—0.147	—0.242
1953	+0.002	—0.141	—0.141	+0.002	—0.141	—0.141

*Loss after adjusting for 5000 bbl leak occurring first months of operation.

†Loss after adjusting for terminal-line and working inventory which occurred as new lines and new tanks were filled with products when first placed in operation. These unavailable products were considered as loss in accounting procedure and were: For 1948—2869 bbl, and for 1949—319 bbl.

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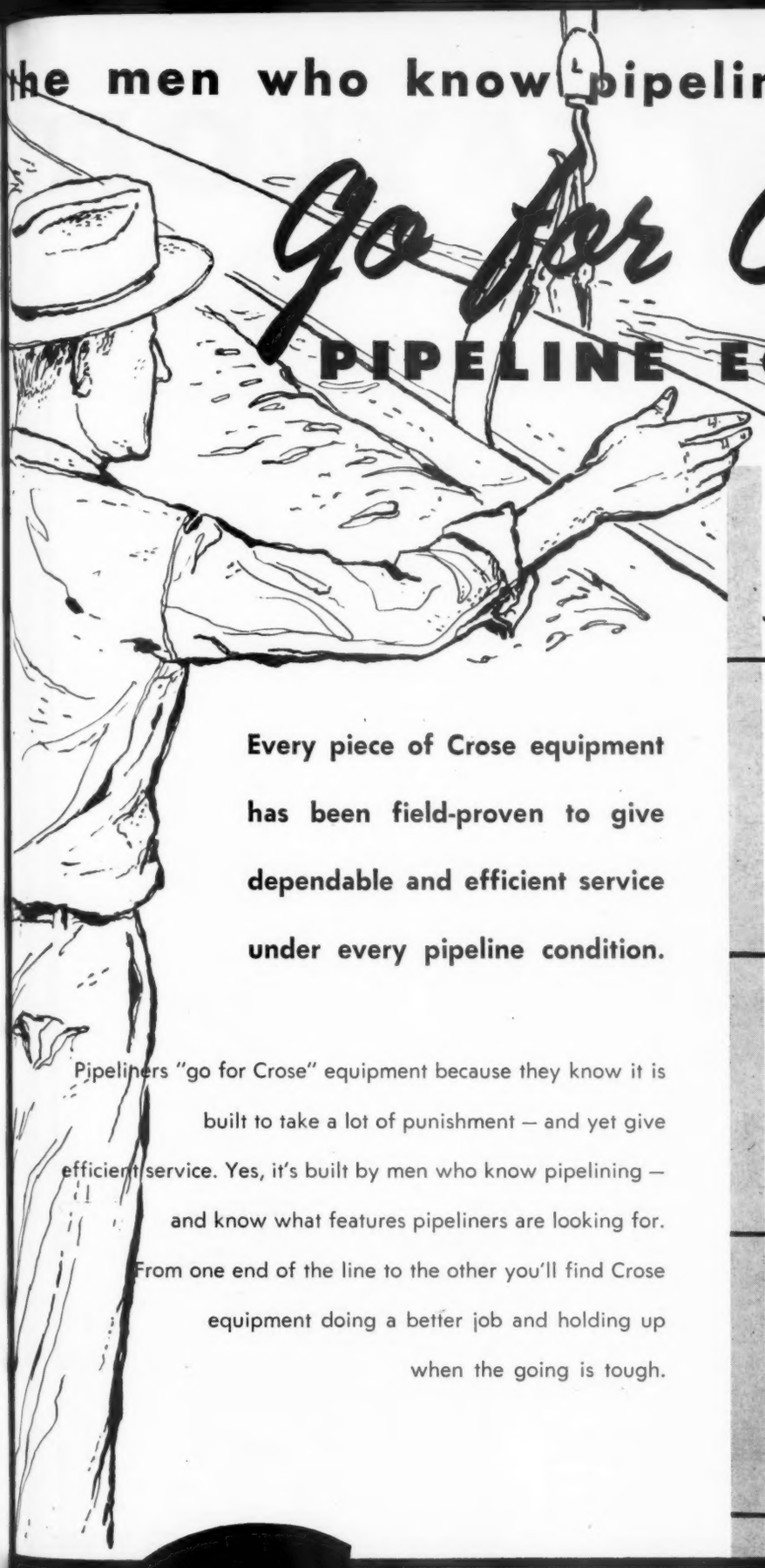
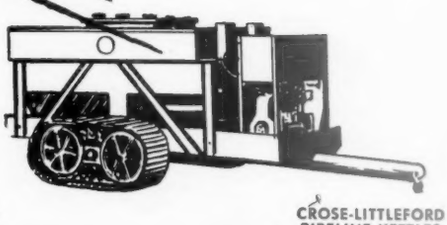
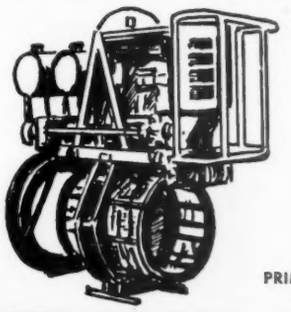
PIPELINE EQUIPMENT





CROSE-LITTLEFORD PIPELINE KETTLES



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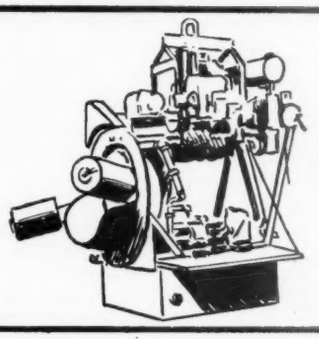

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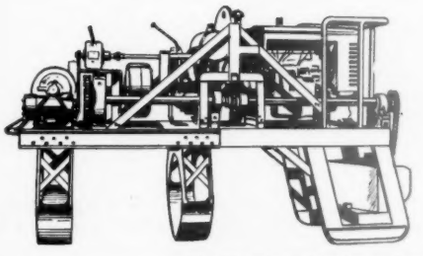

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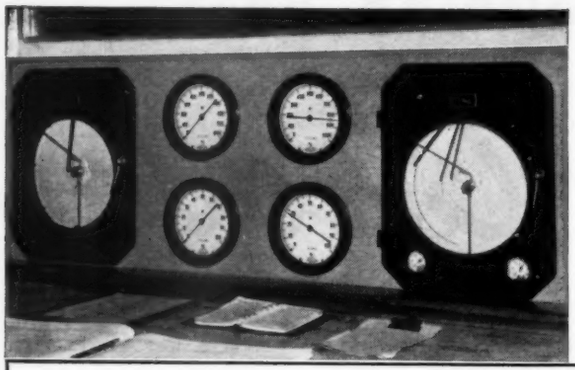
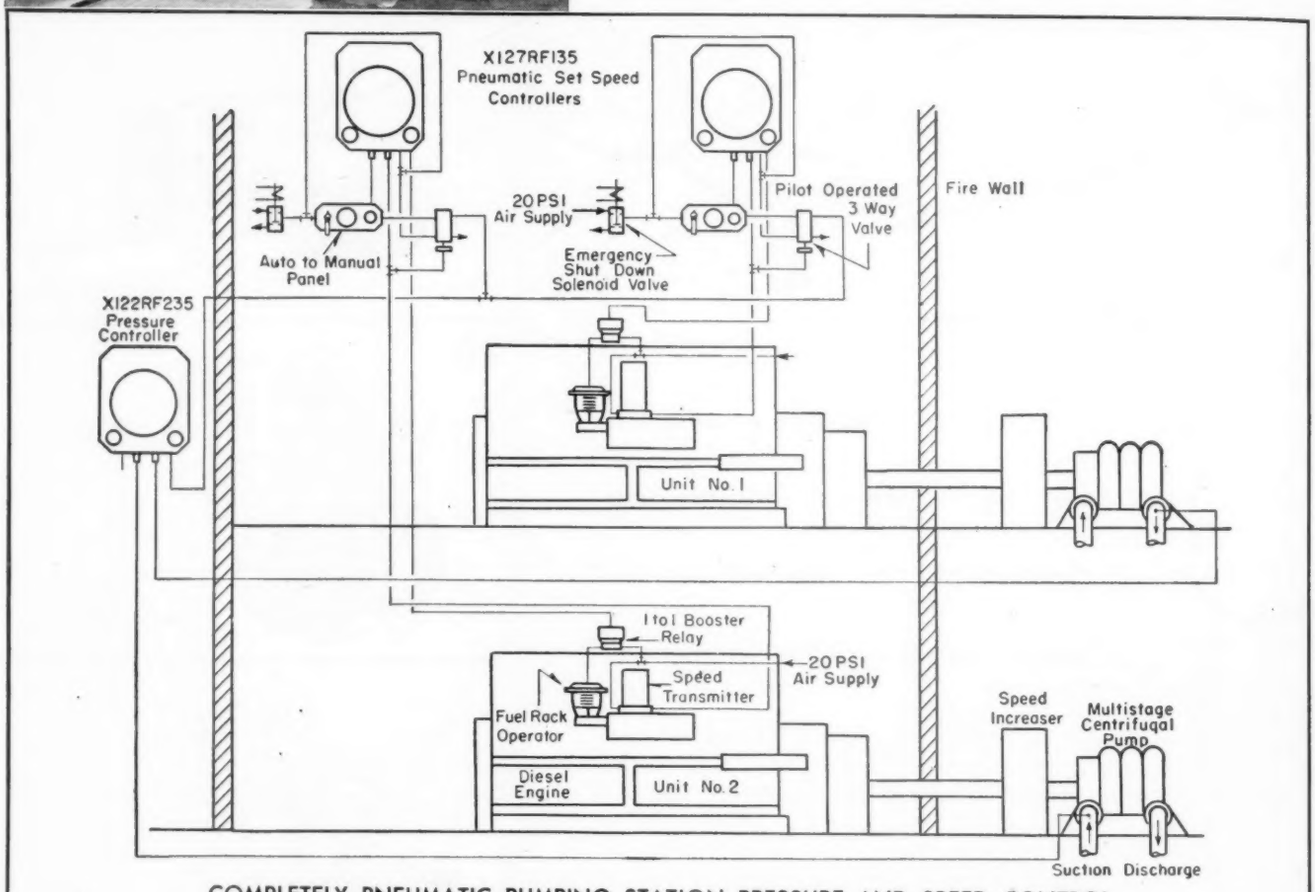


TAYLOR

Central control panel at the Patoka Plant of Texas-Empire. Master Controller for station suction and discharge (right).



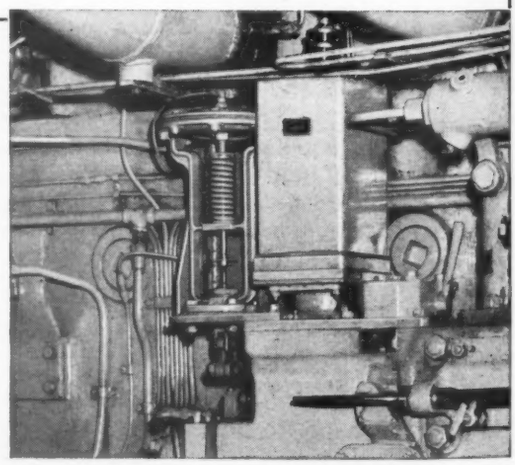
COMPLETELY PNEUMATIC PUMPING STATION PRESSURE AND SPEED CONTROL

Station suction and discharge pressures are controlled and recorded by a master controller in the main control room. Pressures are set at their limits, and control is at the value dictated by existing pumping conditions. The output of this master controller pneumatically adjusts the speed of the two diesel engines to maintain a constant suction—or discharge—pressure. The pneumatic-set speed controllers position the fuel rack to maintain the required speed.

The speed control system consists of a pneumatic speed transmitter which converts diesel engine RPM into an output air signal going to a recording speed controller. Thus a continuous record of engine speed is always available. Speed controller output goes through a booster to the pneumatically operated fuel rack positioner to provide fast action in the event of sudden load changes.

Provision for emergency shut-down by the inclusion of a solenoid operated air valve, immediately vents the system and closes the fuel rack. If for any reason engine speed drops below the normal safe limit, the engine is immediately cut off by a pilot valve actuated by the speed transmitter.

Automatic to manual units assist in start-up of individual engines, which are started up on manual and then switched over to adjustment by the master controller.



Close-up view of Taylor Speed Transmitter and pneumatically operated fuel rack. Speed sensing transmitter converts engine RPM into a pneumatic signal which actuates recording speed controller.

TAKES TEXAS OVER ILLINOIS

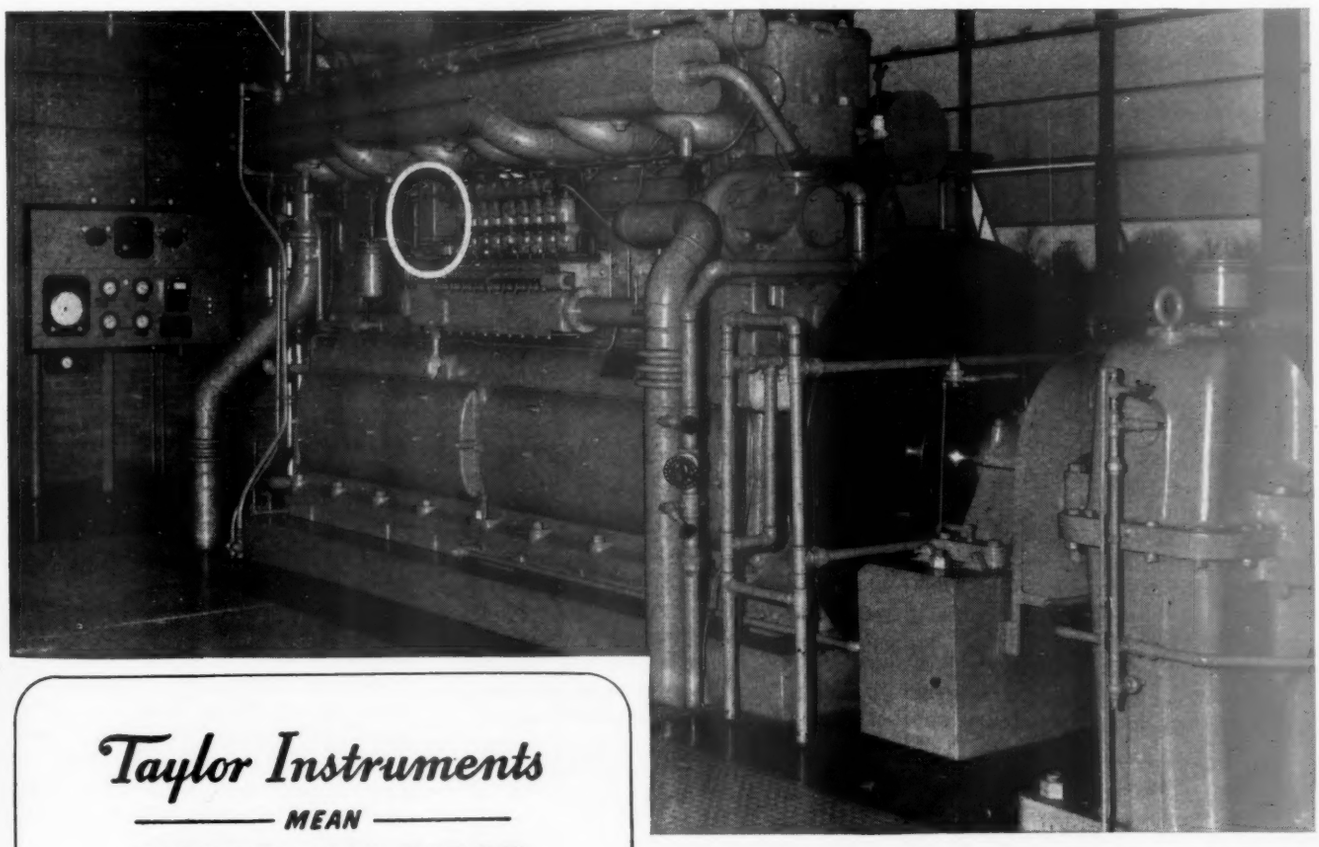
. . . with 100% pneumatic control for pumping stations

AT the Patoka and Bement, Illinois, Pumping Stations of the Texas-Empire Pipe Line Company they control both station suction and discharge pressure *and* engine speed pneumatically. (See drawing at left) This modern answer to the problem of pipeline pressure control, made possible by application know-how and the Taylor FULSCOPE* line of instruments, has several distinct advantages:

1. The basic simplicity and dependability of those pneumatic controllers make them ideally fitted to the problems encountered in pipe line engine speed and station pressure control.
2. FULSCOPE Controllers have proved themselves over the past 15 years.
3. They are easy to set up and adjust for optimum station performance.
4. Maintenance—what little is required—is extremely economical, since station pressure controllers and speed controllers are the same basic instruments.
5. A continuous record of engine speed is available at all times—helpful for engine efficiency checks.

Texas-Empire report high accuracy and rapid response to load changes, keeping the station under fully automatic control. If you have a similar problem why not call your Taylor Field Engineer—or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

*Reg. U. S. Pat. Off.



A Texas-Empire diesel engine under automatic speed control at the Patoka Pumping Station. Panel at left shows the Taylor Recording Speed Controller recording and controlling diesel engine speed as dictated by the Master Controller. The circle shows speed transmitter and pneumatically-operated fuel rack.

Taylor Instruments
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ACCURACY FIRST
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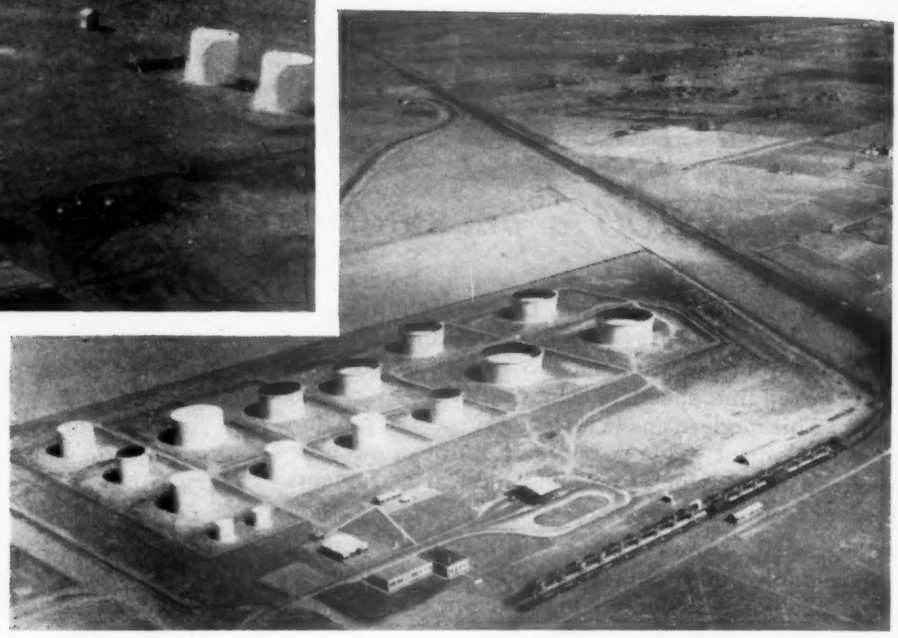
FIG. 4. Aerial view of Strouds main line station.

FIG. 5. Aerial view of Denver products terminal.



ity of theft caused greater safeguards to be taken; however, even with constant vigilance during this period, no irregularities were discovered and losses persisted.

Meter Performance

One change in operating procedure concerning inspection, servicing, maintenance, and testing of pipe line input and output meters occurred during this period of unsatisfactory loss. The change was made to effect a reduction of meter expense.

Table 2 shows a comparison of meter servicing frequency, annual pipe line loss, number of leaks, and meter expense.

Wyco's data, shown in Table 2, indicates that meter accuracy is only obtained with a frequent servicing program, which can be obtained for less than $100 yer year per meter. Our average was $82.28.

When there are no leaks in the trunk pipe line, the closer the per cent annual pipe line loss or gain is to zero, the more accurate performance of the pipe line meters is indicated and can be assumed. Thus, it can be seen that good metering conditions existed in 1948, 1949, 1950, 1953, and 1954 to date. Most of the loss during 1950 occurred, as previously pointed out, in the last quarter after inaugurating longer periods between meter inspections. Very satisfactory results have been obtained during 1953 and, in fact, to date from October, 1952, when the frequency of meter inspection was increased.

The terminal loss, for the most part, remained normal all during the two-year period of continuous pipe line loss. This fact and the fact that pressure tests on the main trunk line were negative indicated that our pipe line loss was an apparent or accounting loss.

Over the long period of time that our loss persisted, no expense in terms of either man-hours or money was spared in our efforts to determine the reason for the loss and to correct same. It is recognized that when consistent losses occur, operators are greatly concerned and additional expense necessary to locate and correct loss often could be only a fraction of the value of the product being lost when a leak actually occurs. Wyco's experiences related herein, however, may serve as a guide to a quicker solution of some operator's problem, resulting in a saving of time and expense.

Table 2.

Year	No. of bbl registered on meter before inspection and repair	Per cent annual pipe line loss-gain	No. of Leaks P.L.	No. of Leaks Term.	Annual meter expense/meter
1948	100,000—200,000	0.168 0.011*	2	0	.....
1949	100,000—200,000	0.001	0	0	$129.00
1950	500,000—1,000,000	0.023	1	0	98.61
1951	500,000—1,000,000	0.101	0	0	None
1952	500,000—1,000,000	0.094	0	1 (Mar.)	76.52
1953	100,000—200,000	+0.002	0	0	110.60
1954	100,000—200,000	+0.003 (3 Mo.)	0	0	.....

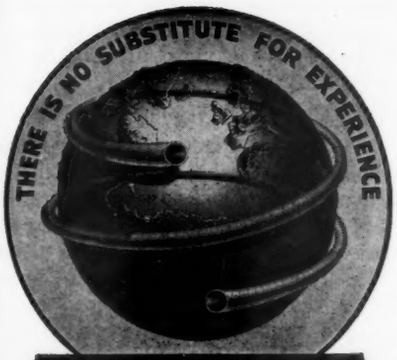
* Per cent annual loss after adjusting for 5000 bbl loss due to pipe line leak.

Operating Methods Utilized by Wyco to Control Losses

Pipe Line Control

Trained Employees. Operating personnel are thoroughly trained to know the peculiarities of our pipe line and especially to recognize conditions indicating a leak. Dispatchers are taught the simple hydraulics of the pipe line and how to analyze unusual conditions. Other operating employees are trained to observe unusual conditions and to immediately notify the dispatcher of such observations so that, if necessary, the line can be shut down and pressure tested.

Working Tools. Simple working tools consisting of charts, tables and curves are provided for the use of dispatchers. A pressure gradient chart is plotted on a large profile map of the pipe line. A pressure scale based on static head of maximum and minimum gravity of products transported is plotted on the map at each station and terminal. A conversion chart for different gravity products permits adjustment to current operations. Curves showing proper holding pressure at terminals have been



CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle on *PIPE PROTECTION*

★

By Boyd Mayes

• Some feller with a big load of 4" broke down his long haul truck outside our establishment and we went out to see while he was waiting for help. We got to talking and it seems he was from the Piney Woods too, so we found one thing *real good* in common. He went on telling me the woes of long hauling and how he hated it and contractors too. Finally, I got around to asking him how long he had been at it and he said 15 years. "That's funny," I says: "If you hate it so how come you keep at it?" He puzzled a minute and then said: "Well, you know there's lots of things *I hate worse.*" All of which goes to show how hard it is to find a man who don't like to talk. Now me, I like contracting — cause everyone I meet is my friend — some are old and some new — some are little in business, some are big . . . but they're all BIG to me. Sometimes they help me — maybe I help them. We all get along pretty well working . . . that's about all all of us do . . . work. Seems that it's not so much the money as the job we're in together — a job well done with friends. Guess that's what they mean when they say — *every call a pleasure.* Yes, I like the contracting business. Seems every day we meet up with old friends — new friends — old timers — new ideas — tried ideas — even some untried — but they all make the day interesting. It's been like that for 26 years — that's our record for working at the main job we know — coating, wrapping and reconditioning pipe. We're proud to offer the best of men and equipment to serve you.

MAYES BROS.

1130 McCarty HOUSTON, TEXAS Orchard 7566

prepared which adjust for friction factor for various rates of flow under different operating conditions. With this information readily available, dispatchers can easily plot pressure gradient. By comparing actual hourly reported pressure readings at various locations with gradient pressure it can be determined that the line is being operated under proper pressure conditions or adjustments can be made.

Method of Measurement. Wyco utilizes positive displacement meters that measure input to the pipe line and output from the pipe line. This equipment is used because of the following advantages.

1. Meters provide the best method of maintaining a more consistent and constant line balance.

2. A more accurate and dependable method of accounting for products is attained.

3. Meters provide the most flexible system of checking line operation, as in case of an emergency a line balance can be obtained on short notice without delay.

4. In normal installations, metering requires less man hours than gaging tanks.

5. A reduction in terminal tankage is obtained when products are metered, because only one tank for each product is required at a terminal. This provides efficient operation as product can be shipped at the same time a tender is being delivered into the terminal storage tank, and accurate accounting of the transactions obtained. If tank gages are used instead of meters, two tanks for each product are required at a terminal — one for receipts and the other for shipments.

6. The use of metering permits a reduction in terminal evaporation loss. In explanation: When using tank gages and two tanks are used alternately, more wetted tank surface is exposed resulting in increased evaporation losses.

Method of Calibrating and Operating Meters. Meters are tested under simulated line flow conditions. The same meter case pressure and same rate of flow as exist when the meter is in service is used when testing meter registration against calibrated proved tank volume. The accuracy of the meter, as well as that of the test, depends upon maintaining meters in first class operating condition at all times.

Calibrating tests are run on each meter until two consecutive meter factors are obtained that do not vary by more than 0.0005. The average of these two factors is used as the meter factor. All meters used in metering products are calibrated as near the middle of the batch as possible.

A comprehensive study indicates that

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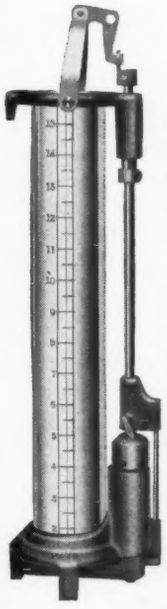

Know if your oil is ready to run. Save yourself time and expense. Use the original Walker-Tulsa Oil Thief.

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Exclusive features include: single tripping device; a rotating valve seat to assure proper seating; encased springs to prevent fouling; trip mechanism which accommodates any length trip rod. Sturdily built for longer service. Available in five sizes: 12, 16, 18, 24 and 36 inches. Available through all supply stores.

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Everything the gauger needs from one dependable source.

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meter factors change 0.0002-0.0003 for each degree API change in gravity. An increase of API gravity will increase the factor, and a decrease of API gravity will decrease the factor.

Meters are set to run with an approximate meter factor of 1.0000 on 60 deg API gravity gasoline. If a product change occurs and 41 deg API gravity kerosine is being metered, the estimated meter factor used by the dispatcher would be 0.9962. This would be utilized until a meter test was run and the meter factor for the kerosine batch determined. After the actual factor is obtained, adjustments are made on the total volume metered.

During 1952, a series of tests conducted on all pipe line meters showed that variations of pressure and rate of flow within the rated limits of a meter caused no appreciable change in the meter's accuracy. The accuracy of meters remained within the limits claimed by the manufacturer.

Operating with a Balanced Line. The line balance of input volumes versus output volumes is maintained thus:

Meter readings at all locations are reported hourly to the dispatcher, who adjusts by respective meter factor and then corrects to 60 F.

Gasoline composes 83 per cent of volume transported; consequently, when a meter has been repaired, and before being placed in service, a preliminary test is made and the calibrator is set so that the meter will register gasoline volume as closely to the volume in the proving tank as possible. Such adjustment permits meters to run at approximately 1.0000 when first placed in service after being repaired and provides a more uniform line balance before the actual meter test is made as provided by Petroleum PD Meter Code No. 1101.

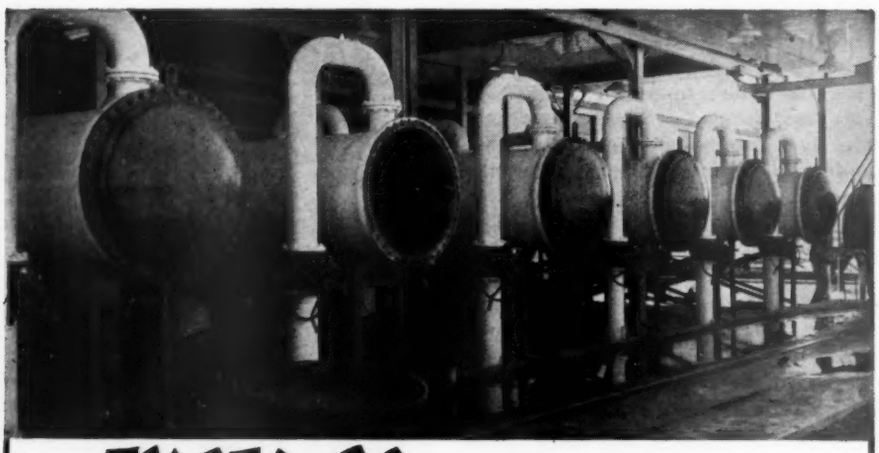
A meter set to run at approximately 1.0000 may have a factor of 1.0005 or 0.9995 on an actual meter test. This means that the difference in input or output would amount to only 5 bbl in each 10,000 bbl pumped or received until the meter test is run. At a pumping rate of 1000 bbl per hour, this error would be negligible in hourly reports. If this procedure was not followed, the error could be considerable, and over a ten-hour period cause much concern for the operator.

Packed Line. It is most important, especially in mountainous terrain, to operate with a packed line to maintain accurate metering conditions for detection of leaks and to reduce commingling of products moving through the pipe line. A line is considered "packed" when it is full of products with no separation of fluid occurring therein. It is accomplished by maintaining a positive pressure on the entire length of pipe line so that the minimum pressure at any point in each section is slightly above the required hydraulic gradient pressure at that location.

Method of Pressure Testing Lines. When it has been ascertained that a situation exists necessitating a pressure test, the chief dispatcher supervises the test, and the following steps are taken:

1. Intermediate stations are shut down, main line station by-pass valves opened, and intermediate station suction and discharge valves closed to isolate such stations from the main line.
2. The main pump station reduces pumping to one variable stroke unit.
3. The headgate at Denver is gradually closed, and when pressure at Cheyenne reaches 275-285 psi pumping is stopped and station headgate closed. These pressure conditions have shown by experience to provide 225 psi pressure at the highest point on the line and not over 1200 psi pressure at any point on the system. Normally, these conditions provide ample pressure and sufficient time to determine if a leak exists and in what segregated section it occurs.
4. Twenty minutes are allowed after all stations and terminal headgates are closed to permit pressure to become stabilized in the line. Employees then close predetermined main line block valves located approximately 25 miles apart. Pressure gages are installed on each side of main line block valves that are closed and readings taken and recorded every 15 min. A pressure drop in a segregated section not exceeding 1 to 5 psi hourly is not considered indicative of a leak. This occurs because temperature changes of product in the line, particularly in river crossings, cause product to cool, resulting in lower pressure gage readings. Should a consistent drop in pressure exceeding 5 psi per hour be noted in a segregated section, the reader would go to the nearest telephone and notify the dispatcher, who immediately directs pipeliners to go to such area for the purpose of locating a leak.
5. The dispatcher then arranges to reduce pressure in such section as low as possible consistent with the location, but not lower than a predetermined maximum static pressure head existing at pressure gages on the inside of the segregated section. This procedure is utilized when a high point exists in the segregated section in which a leak is indicated to further isolate the area of the leak.

After a pressure test and line repairs are made pumping is resumed after the dispatcher has ascertained that all main line block valves are open. Our experience has shown that a satisfactory test requires 6 to 8 hours with blocked-



EXCEL-SO Combination
SEPARATOR – FILTER – AIR ELIMINATOR
. . . for removal of bulk quantities of water, pipe scale, and rouge from products Pipelines . . . . .

These HPQ-1000 SC Separators are in use at Plantation Pipe Line Company's Baton Rouge Pumping Station. Today, more and more Products Pipe Line Companies are using EXCEL-SO Units to remove water and dirt from products streams either as primary coalescers or as first-stage units in connection with desiccant dehydration.

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The reliable way to control your pipe line—

UNION Centralized Transport Control

When you use Union Centralized Transport Control on your pipe line you have reliable control of the complete system at your finger tips. Each of the many different operations can be quickly accomplished by merely positioning a switch in the central dispatching office. And conditions on the line are clearly indicated on the control panel.

Union Centralized Transport Control is simple in operation and utilizes rugged equipment that has been thoroughly proved. It stays on the job without constant attention by trained electronic experts. Control equipment is mounted behind the panels in convenient, plug-connected units that will operate for years with a *minimum* of maintenance.

This system is a practical adaptation of C.T.C. (Centralized Traffic Control) which for more than 25 years has controlled the intricate and extensive movements of railroad trains the world over. Working on exactly the same principle, Centralized Transport Control will bring your pipe line closer to complete economy and efficiency of operation.

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Please send me your new booklet which describes the many advantages of Union Centralized Transport Control for Pipe Lines.

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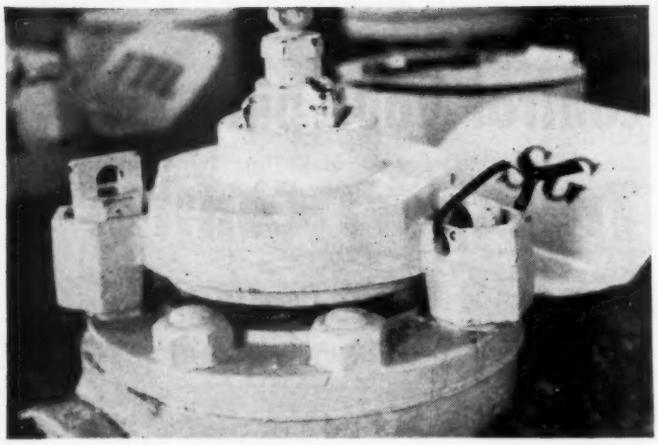


FIG. 6. Sealing device used at terminal manifold.

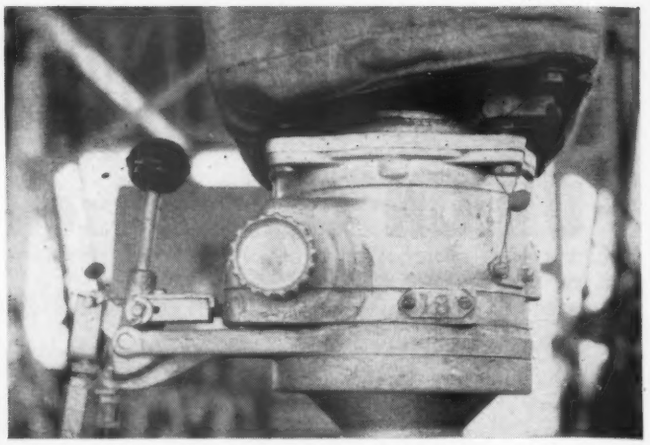


FIG. 7. Sealing device used at truck dock meter.

off sections of approximately 25 miles in length but in no event exceeding 50 miles.

6. During the time a pressure test is being made on the main pipe line between headgates at all locations, a pressure test of 100 psi is made between the headgate and the tank on stream at each terminal. This test includes manifold piping and facilities such as strainers, settling tanks, meters, valves, etc. A similiar test is made on station piping and facilities. Pressure tests on all other buried terminal piping are made on an established schedule.

In an effort to assure low losses, a pressure test of the main trunk line and terminal and station lines and equipment is made annually during a period of low pumping requirements.

Also, if sufficient time is available whenever the main line is shut down for other reasons, a pressure test is made.

It is our policy to pressure test at the earliest possible time after the main trunk line has been opened for repairs or changes.

Terminal and Station Control

Trained Employees. Employees are trained to know the value of products, the importance of minimum commingling, the danger of spills and fire hazards, the importance of properly setting set stop meters to prevent spills, and the effect of over or under loading tank cars. Stress is placed on noticing leaks or spills; cleaning up spills; stopping leaks promptly — such as tightening packing on valve stuffing boxes, pump packing glands, flanges, swing joints, and the prompt repair of faulty equipment. Fire drills are conducted, and each employee learns how to use fire protection equipment, how to care for and inspect same periodically, and to have confidence in the use of fire fighting facilities provided. Employees are trained to keep sealed and locked all possible sources where products could be improperly removed from the system. They know such procedures protect both the company and the employees. The excellent results attained in loss control could not have been obtained without the full and complete cooperation of all Wyco employees.

Safety Program. The carrying out of a planned safety program has resulted in efficient and economical operation. Workmen usually are assigned a safety meeting, select the subject to be presented and lead the discussion. Each employee would perform this duty once in each six month's period. Results are few errors, fewer spills from loading trucks and rarely any difficulty in loading tank cars shell full. Spills, should they occur, are promptly cleaned up before continuing with loading operations. The carrying out of operations in a safe manner also minimizes the possible loss from fire by reducing or eliminating fire hazards except those which are inherent with pipe line operation.

An example of an inherent hazard would be the tank or truck full of vapors that roll out the top of the equipment as it is loaded with volatile products. Discussions occurring in safety meetings often bring out practical suggestions from employees on reducing or preventing losses. Quite often such suggestions are adopted as part of our operating procedure, or where necessary, changes are made to facilities.

Safety Truck Loading Spout. The original truck dock loading spouts were constructed with an open bottom end cut on a 30-deg angle from vertical. With this construction, it was thought that product being loaded would spread out along the bottom of the tank truck. This did not occur, because the momentum of the stream caused by the rapid loading rate forced the light weight loading spout upwards. On occasions the force was sufficient to actually cause loading spouts to rise completely out of the loading man hole in the top of the tank truck, causing a product spill and loss.

This condition was corrected by closing the ends of the truck loading spouts and cutting four slots in the sides of the spouts just above the closed ends. This change in spout construction did not restrict flow, and as a consequence has eliminated this problem and, further, has provided a simulated bottom loading effect.

Inspection and Maintenance. A complete maintenance and repair program is, or soon will be, in operation which covers all equipment at all locations. A check and repair list for each piece of equipment is maintained covering all items to be inspected and repaired, date of inspection and repairs, and actual work performed. Every effort is made to keep all operating equipment free from leaks and in excellent physical condition with a frequent schedule of inspection. This policy has paid dividends in reducing losses and fostering a real pride and enthusiasm among employees "to keep things clean and prevent waste." All products loaded into trucks at terminals are loaded through set stop meters which are calibrated every sixty days and sealed to prevent tampering. Meter calibrators or meters are changed if calibrator cannot be adjusted to permit meter accuracy to fall within limits specified in Petroleum PD Meter Code No. 1101.

Protective Storage. Floating roof tanks are inspected regularly to ascertain that seals are in good operating order and evaporation losses held to a minimum. The level of product in a tank is never below that which is required for the roof to float. Tanks are painted white to insure minimum evaporation loss. In so far as possible, scheduling is arranged to minimize evaporation losses from wetted tank surfaces.

Accounting Methods. Complete records are maintained on daily operations, and a daily operations report is prepared covering all transactions. A

daily product inventory (not corrected to 60 F) is taken. After adjusting for receipts and deliveries, the actual inventory on any product must check within fifty barrels of the calculated inventory or an immediate investigation is undertaken to ascertain where the error occurred in the previous day's operations. Thus, a comprehensive check is maintained on each day's operations and any unusual conditions are discovered and immediately rectified. A daily meter report showing the total amount of each product metered by individual meters into trucks is checked against respective truck orders. These totals must be the same.

Security Measures. In order to reduce losses and prevent unauthorized use of products in Wyco's custody, a security program in cooperation with the Tax Evasion Committee was adopted. This has been in effect for several years and has recently been reviewed, and additional precautions and improvements are in the process of being adopted.

Some of the measures adopted are as follows:

Valves on incoming shippers lines are sealed with a numbered seal each time it is necessary to operate the valve. Recorded in the seal book is the following information on each seal used:

Seal number
Valve number
Date sealed
Initials of person installing seal
Date seal removed
Initials of person removing seal
Reason seal removed

Valves at terminal manifolds on lines to individual tanks are sealed and handled same as above. Fig. 4 shows a sealing device on a terminal manifold valve.

The following are locked with a company padlock:

Main line block valve housings.
Unattended stations and cyclone fence surrounding same.
Water draw valves on tanks.
Pump-out connections at truck docks and tank car loading racks.
Connections to system at unattended locations.

Unused connections are blinded off.

The pipe line is air patrolled twice each month and any suspicious activity reported is investigated within twenty-four to forty-eight hours.

All pipe line input meters, all pipe line delivery meters at terminals, and all delivery meters at the truck docks, including ticket printers, are sealed and a record made of each sealing. These are lead sealed with a Wyco seal by the supervisor in charge of the location. Meters sealed in this manner are inspected weekly by the respective supervisors. Should a seal be found broken during an inspection, an immediate investigation is made and the reason determined. Fig. 7 shows a sealing device on truck dock meters.

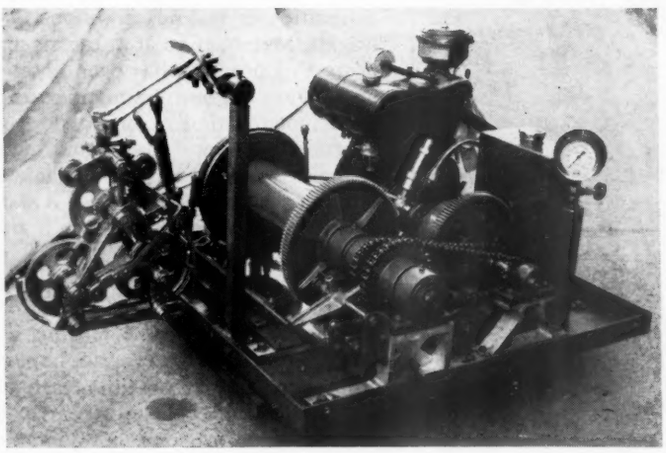
All tank cars and transport trucks over 1500-gal capacity are sealed after loading. Records are kept of all numbered seals.

All openings on the system used for any purpose are either sealed, plugged, or blinded off when not in use. Thus, product cannot be drawn out of a pressure gage connection, a drain connection, or an unused connection by merely opening a valve.

Problems

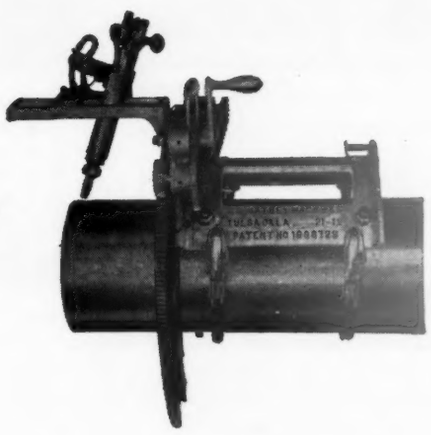
Free Water in Product. Most pipe lines encounter occasions where shippers pump free water along with the tender. This occurs when water is not properly drawn off the tank from which the tender is being pumped, or, in case delivery is made from tanker or barge, water ballast was not completely eliminated. In such cases all free water pumped into the pipe line system along with the tender is metered or gauged at origin and ultimately results in loss when the tender arrives

MATHEY MEASURING LINE REELS



WITH MEASURE METER AND SPUDDER ATTACHED

Mathey portable measuring units are designed for mechanical location of the bottom of the hole or distance to fluid or hole obstacle. Driven by a gas engine or power-take-off, Mathey units can be mounted on trailers, in autos, on pulling units or core drills. Reel capacities from 5000′ to 18,000′. Measure meter with weight indicator gives length and weight of line.



MATHEY PIPE CUTTING AND BEVELLING MACHINES

Available in 5 models for pipe from 4″ to 36″, Mathey Pipe Cutting and Bevelling machines cut pipe at any predetermined angle. With attachments, Mathey machines will cut shapes and coupons as well as out-of-round pipe.

C. A. MATHEY MACHINE WORKS

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at the destination. While in most instances losses are relatively small from this source, they do occur.

Air in System. There are occasions when air gets into a pipe line system, usually after repairs are made. If air is not vented and completely eliminated before arriving at the destination meters, damage to metering equipment could occur. If such damage is not immediately detected and corrected, inaccurate meter readings can result.

Sediment in Products. There are occasions when suspended sediment is pumped along with product into pipe lines. Such conditions, if continued for any period of time, will cause excessive wear of both origin and destination meters. Metering inaccuracies can then occur as well as excessive meter expenses. Continued alertness in recognizing such situations and checking meters is about the only safeguard against such accounting losses. Pipe line systems using tank gauges as a means of product accounting are not affected by such situations.

Effect of Temperature. In correcting hourly input and output meter readings to 60 F, it has been noted that the line will balance when the temperature of the product entering the pipe line at the origin meter is almost identical with the temperature of the product in the line. The line temperature is considered equivalent to the temperature of the product leaving the pipe line at destination meters. However, if the temperature of the product entering the line at the origin meter is lower than the line temperature, line balance corrected to 60 F will run short hour by hour.

Conversely, if the temperature is higher than line temperature, the line balance will run over hour by hour. Completed batch reports will show similiar discrepancies. It is realized that the temperature of the product entering a pipe line will reach an equilibrium temperature within the first few miles. We have not yet been able to account for this phenomenon and believe it merits consideration by others. An explanation of this might account for the reason some pipe lines have tendency to run short during cold weather and over during hot weather.

Meter Inaccuracies When Changing Type of Product Material. At a constant pressure when changing from gasoline to distillates the meter should register more throughput because of less slippage with distillates. Conversely, when changing from distillates to gasoline the meter should register less throughput because of more slippage with gasoline. Completed batch reports of distillate tenders following a gasoline tender nearly always show a gain. Completed batch reports of a gasoline tender following distillate show a loss.

Normally, the conditions existing when calibrating or testing meters at terminals more nearly approach the actual meter operating conditions than calibrating or testing conditions do at origins. Meter action at terminals upon change of products has been observed to function in a normal manner. However, meter action at origin does not function as anticipated and when changing from gasoline to distillate the line balance shows an overage. A shortage is shown when the change is from distillate to gasoline.

It is possible that the meter calibrating procedure at the origin locations could be improved and this situation eliminated. However, we have not been successful in obtaining satisfactory results and believe others might give this problem some consideration.

Summary

In conclusion, it should be recognized that there is no intent in this article to promote any specific equipment nor any method of operation. The objective was to present the Wyco Pipe Line Company loss picture based on our own facilities and our own method of operation together with some ideas concerning this economic problem. It is sincerely hoped that our efforts have been helpful. * * *

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3½"	5	115	255	15	700	

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Pipe Line Projects

Transco Authorized to Increase Capacity

The Federal Power Commission has authorized Transcontinental Gas Pipe Line Corporation, of Houston, Texas, to construct pipe line facilities that will increase the sustained delivery capacity of its system by 20,000,000 cu ft of natural gas a day.

Transcontinental will construct a total of about 57 miles of 30 and 36-in. pipe paralleling sections of its existing system in Louisiana, Mississippi, and Alabama. Estimated cost of the project is $6,533,000.

Seven loads of yard-coated 20-in. pipe, 13 joints to a load, are shown ready for departure at Houston. Pipe is going to Magnolia Pipe Line Company's 200-mile Corsicana-Beaumont crude line project. Dunn Brothers, Inc., Dallas, has hauling and stringing contract; H. B. Zachry, San Antonio, is prime contractor.

New Facilities for El Paso Natural

The Federal Power Commission has issued a certificate to El Paso Natural Gas Company, of El Paso, Texas, authorizing it to construct pipe line facilities in Lea County, New Mexico, and Crane County, Texas, to enable it to acquire additional natural gas in the Permian Basin area.

The project will include construction of a total of 13.3 miles of pipe line, 1540 hp in compressor capacity, and a purification and dehydration plant. Estimated cost of the construction is $3,295,589.

FPC Approves TET-Transco Plan, Penn-Jersey Line

Texas Eastern Transmission Corporation has received FPC approval of its proposal to render a gas storage service to Transcontinental Gas Pipe Line Corporation. Under the plan, Texas Eastern will store for 20 years in its Oakford underground storage field 12 billion cu ft of natural gas per year for Transcontinental, delivering the gas to Transcontinental in the winter at a daily maximum rate of 133,500,000 cu ft and receiving redelivery of the gas from Transcontinental during the summer months. Transcontinental has agreements with seven of its customer companies in the New York, New Jersey and Philadelphia areas, providing for delivery of the gas to such companies under similar terms.

At the same time, Texas Eastern Penn-Jersey Transmission Corporation was granted a certificate for construction and operation of a natural gas pipe line starting at the Oakford storage field and extending to a point of connection with Texas Eastern Transmission Corporation's lines near Lambertville, New Jersey. Construction of the 265 mile 24-in. line will start immediately. It will have a daily delivery capacity of 204,000,000 cu ft, and will be built at an estimated cost of $31,000,000. The line, scheduled for completion by the fall of 1954, will be leased to and operated by, Texas Eastern Transmission Corporation.

Ohio Fuel Gas Files For 20-in. Pipe Line

The Ohio Fuel Gas Company, of Columbus, Ohio, has filed an application with the Federal Power Commission requesting a certificate authorizing the construction of 24.5 miles of 20-in. pipe line in Richland and Crawford counties, Ohio, to enable it to transport additional natural gas from underground storage.

The proposed new line, estimated to cost $1,072,000, would extend from the company's Weaver storage compressor station in Richland County to the junction of two existing lines in Crawford County.

Montana-Dakota Asks Permit for Gas Line

Montana-Dakota Utilities Company, of Minneapolis, Minnesota, has filed an application with the Federal Power Commission requesting authorization for the construction of a total of about 49 miles of pipe line and an additional 440 hp in compressor capacity on its natural gas transmission system in Montana and South Dakota.

The company proposes to build about 34½ miles of 12¾-in. line paralleling a section of the existing line which extends from the Baker-Glendive field in Montana to Rapid City, South Dakota. The proposed new loop line would extend from a point in Lawrence County, South Dakota, in a southerly direction to the Rapid City town border station. The proposed additional 440 hp compressor unit would be installed at the company's existing Little Beaver station in Fallon County, Montana.

Montana-Dakota also plans to construct a total of about 14.2 miles of 12¾-in. line to replace various sections of transmission mains in lines in Park County, Wyoming, and Carbon County, Montana, extending from Elk Basin compressor plant to Billings.

Total estimated cost of the proposed construction is $1,366,944.

Gas Grid System Proposed For Alberta Area Fields

Amid increasing expectations that no start will be made this year on the large diameter export gas pipe line from Alberta to eastern Canada, the Alberta Government has introduced legislation at the current legislative session to provide for construction and operation of a general grid pipe line system to gather gas from all possible sources in the province. The grid system will be built by a private company, and at least two companies have already indicated their intention to apply for permission to set up such a system.

A grid system such as is visualized by the Alberta Government will require several hundred miles of pipe, as the major fields from which the export line will draw its supply are spread over an area from Cessford in the southeast to Bonnie Glen-Westerose in the north central region and, in the other direction, to Pincher Creek in the extreme southwest. These three fields form a triangle with sides varying from 150 to 300 miles in length and enclose several gas fields of indicated substantial potential.

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Weather Continues Delay On Interprovincial Work

Continued wet and cold weather and road bans have delayed start of construction of the Manitoba and eastern Saskatchewan section of the Interprovincial Pipe Line Company main line loop by Anderson International Contractors, Ltd. Stringing contract for the entire 200 miles in this job has been awarded to Canadian Parkhill Pipestringing, Ltd., under foreman Jim Stubblefield, who has set up office at Winkler, Manitoba, end of the first 19¾-mile section. Unloading has been completed for this section but stringing was not scheduled to start until road bans were removed. Two days of snow occurred at the beginning of May.

Anderson's spread superintendent Buster Watson has deferred his proposed start date from early May to June 15 on account of ground and weather conditions. On the central Saskatchewan section of 100 miles, spread superintendent Wayne Johnson was expected to be well underway in early June, subject to pipe deliveries, which were three weeks behind schdule.

Robert L. Williams will be chief inspector for Interprovincial, with Don Cummings as checker.

Shenandoah Construction Receives FPC Approval

FPC has affirmed, with modifications, the intermediate decision of a presiding examiner authorizing Shenandoah Gas Company, of Lynchburg, Virginia, to construct a natural gas transmission line to supply markets in northern Virgina and northeastern West Virginia.

Shenandoah's proposed pipe line will connect with Atlantic Seaboard's facilities near Middletown, Virginia, and will extend through the Shenandoah Valley, via Winchester, Virginia, to Martinsburg, West Virginia, where it will connect with the existing distribution system of Martinsburg Gas and Heating Company. The system will consist of about 40 miles of main pipe line. Initial construction cost is estimated at $1,553,450, with proposed additions through 1958 bringing this up to $1,860,587.

Trunkline Asks Permit For New Mississippi Crossing

Trunkline Gas Company, Houston, Texas, has filed an application with the Federal Power Commission requesting authorization for the construction of a new crossing of the Mississippi River on its natural gas transmission system.

The new crossing would be located just north of the existing crossing in the Greenville, Mississippi, area. The company says location of existing lines has deteriorated to the extent that the crossing is considered to be in possible danger.

The proposed new facilities, estimated to cost $2,960,000, would include two 24-in. lines crossing the river, together with interconnecting lines to link the new crossing with the company's system. The application says that the new lines would be used simultaneously with the existing lines. Trunkline's system extends from Allen, Texas, to Tuscola, Illinois, and the company transports natural gas to Panhandle Eastern Pipe Line Company and to several small communities in Illinois.

Northern Natural Files For 167-Mile Extension

Northern Natural Gas Company, of Omaha, Nebraska, has filed an application with the Federal Power Commission requesting authority to construct a 167-mile extension of its pipe line in Minnesota to supply natural gas to Duluth, Minnesota, and Superior, Wisconsin area.

Total estimated cost of the proposed project is $12,195,300. Northern Natural plans to build 166½ miles of 24-in. line extending northward from the Farmington, Minnesota, junction of its existing facilities to a point near Duluth. From this main line extension, the company would build a total of 44½ miles of branch lines and town border stations to serve Duluth and Superior. An additional 2000 hp compressor unit is proposed for its Sunray compressor station in the Panhandle (Texas) field.

Hope Natural Gas Files Two Applications

Hope Natural Gas Company, of Clarksburg, West Virginia, has filed two applications with the Federal Power Commission, one proposing to increase the capacity of a natural gas storage area and the other requesting authorization for the construction of an extension of a pipe line into gas producing fields.

In its first application Hope is proposing to increase the capacity of its Kennedy storage pool in Lewis and Harrison counties, West Virgina, by 10 billion cubic feet of gas, to a total ultimate capacity of 30 billion cubic feet. Estimated cost of the project is $1,571,396.

The capacity increase would be carried out by reconditioning, redrilling, replugging, or drilling of additional wells, and the construction of a necessary field gathering system. The construction would include a total of 19.9 miles of 6 to 16-in. gathering lines.

Crude Line Outlet For Canadian Field Uncertain

Whether the Sturgeon Lake crude oil pipe line will be authorized this year and, if so, what route it will follow, is yet to be decided by the Alberta Petroleum and Natural Gas Conservation Board.

Against the two proponents of a pipe line connection into the Trans Mountain line near Edson, west of Edmonton, are three companies, two of which state they intend to submit their own plans at a later date. Other opponent is Amerada Petroleum Corporation, discoverer of the straggling reef field and principal operator in the area. Two applicants for a permit to build the line are Consolidated Gathering Systems, Ltd., and Sturgeon Pipe Lines, Ltd. Opposing are Canadian Decalta Gas and Oils, Ltd., Alberta independent producer, and Territorial Pipelines, Ltd., backed by a Calgary investment firm.

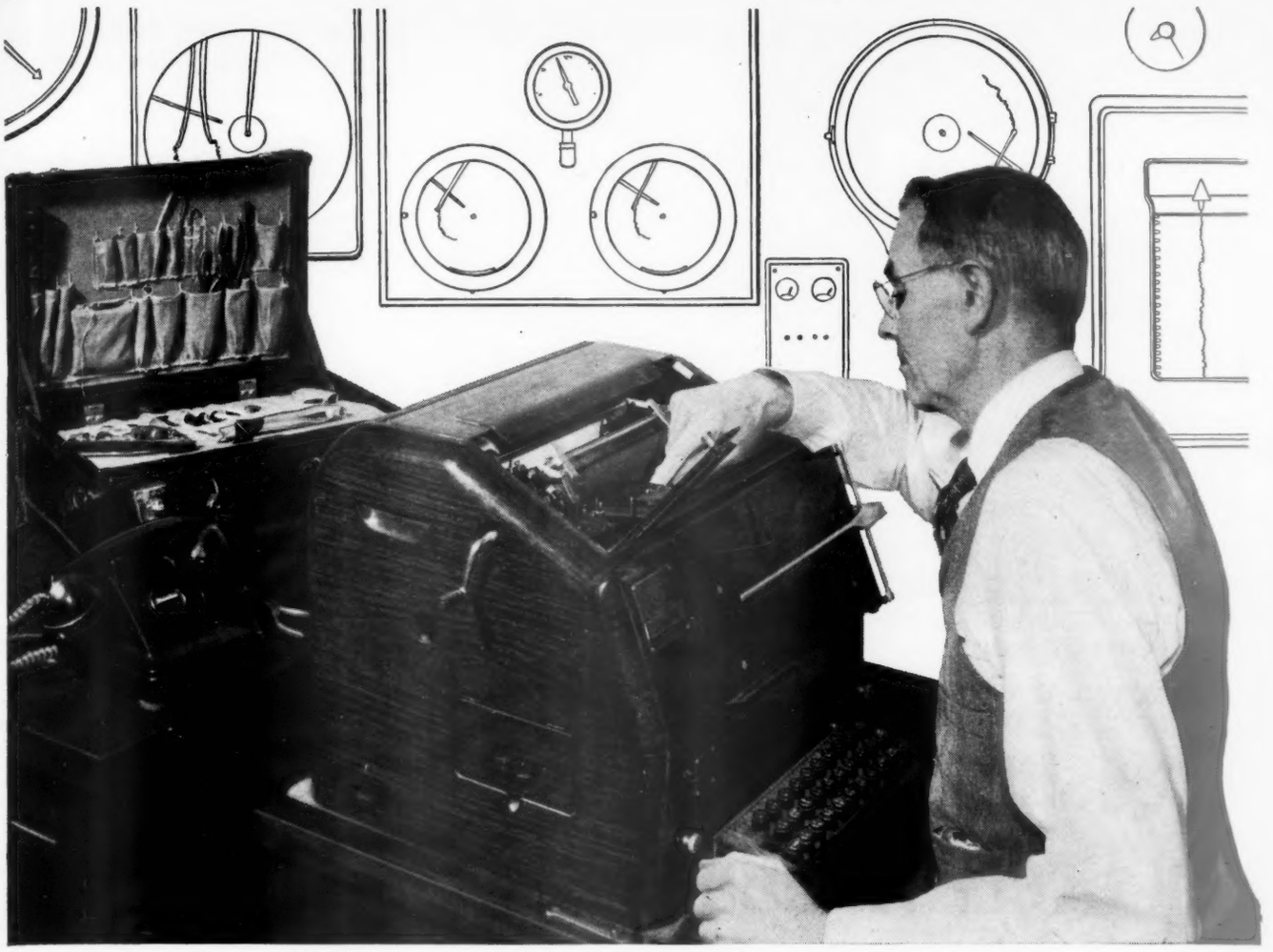
Proposed route would be 115 miles, while a route to Edmonton would take 175 miles but would give access to both trunk lines and provide flexibility. If the Conservation Board's recent decision on the Pembina pipe line can be taken as a guide, it would preclude authorization of either Sturgeon Lake proposal, as it was based on refusal to allocate specific fields to specific markets. Such allocation would interfere with the general production prorationing system, under which field production varies substantially by months according to refiners' requirements but is equated among all fields in the province.

United Fuel Gas Line Contract Given Price

Contract for the construction of a 57-mile, 30-in. pipe line in West Virginia, has been awarded to the H. C. Price Co., Bartlesville, by United Fuel Gas Company, Charleston.

Right-of-way clearance has begun on the United Fuel project, which starts on the west bank of the Big Sandy River, south of Catlettsburg, Kentucky, and extends in an easterly direction to a point about six miles northwest of Charleston. In addition to the 30-in. main line, the Price company will also construct multiple crossings of the Big Sandy and Kanahwa rivers. Both crossings call for three 20-in. lines.

Gas will be delivered to United Fuel at the Big Sandy River by the new Gulf Interstate Gas Company system, which extends from southern Louisiana to the Kentucky-West Virginia border. United will funnel the gas into the pooled supply of the Columbia Gas System for eventual distribution to consumers in a seven-state area.



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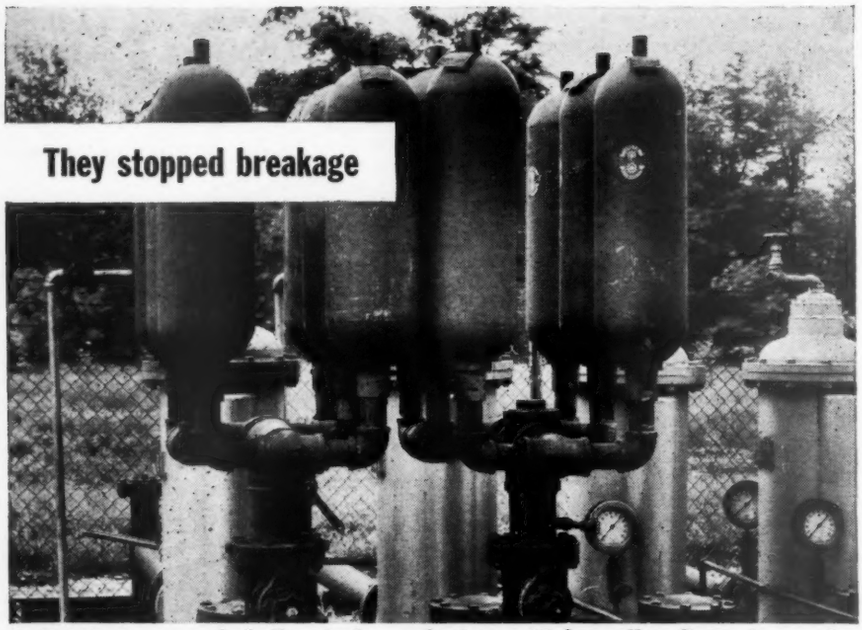

Gulf Oil's Tonawanda bulk petroleum plant uses 12 five-gallon Greer Accumulators in two manifolds to suppress valve closure pressure surges. Read details below.

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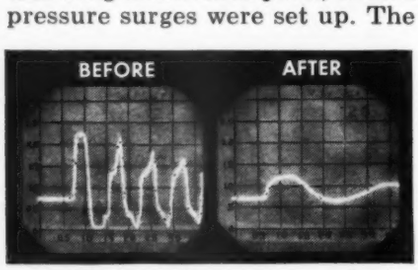
Flowmeter breakage and line failure eliminated when Greer Accumulators reduce valve closure pressure surges from 235 psi down to 125 psi.

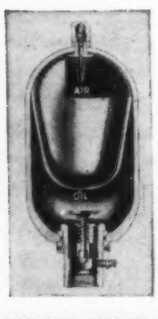
Whenever a valve was closed at Gulf's big distribution plant, sudden pressure surges were set up. The characteristic water hammer noise was heard and—more important—flowmeters were broken or their accuracy impaired.



Hydrauliscope photos give conclusive evidence: line surge was reduced over 100% when 3 valves were closed at once.

It seemed a complicated problem, yet the solution was simplicity itself. Six 5-gallon Greer Accumulators were manifolded to each truck-loaded rack inlet pipe. The accumulators absorbed most of the shock and—by lengthening the time-pressure relationship—took the impact out of what surge remained.

If you are concerned with a pressure surge or pump pulsation problem, our experienced application engineers can show you how Greer Accumulators solve it. Call or write.



How accumulator works: When system fluid is forced into accumulator under pressure, the gas in bag is compressed. Thus the rubber bag absorbs impact to an extraordinary degree. Write or call for Brochure 600 that gives data and diagrams on line shock suppression. *U. S. Pats. under Olaer Lic.*

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Projects

Platte Expansion Calls For Four Stations, Enlargements

Platte Pipe Line Company will expand its capacity to 195,000 bbl per day under an expansion program that will require an expenditure of $2,700,000 to build four new stations and to enlarge five existing stations. Work will be completed by late summer.

New stations will be located near Moorefield, Nebraska; Deshler, Nebraska; Hiawatha, Kansas; and Bosworth, Missouri. The stations to be enlarged are those near Gurley, Nebraska; Holdrege, Nebraska; Marysville, Kansas; and Gower, Missouri.

All of these stations except Gurley will be remotely operated and supervised by microwave from Platte's headquarters in the Power and Light Building in Kansas City. Platte pipe line was completed in December, 1952. Traffic has increased steadily since then. The stations at Holdrege, Nebraska, and Gower, Missouri, are now in the process of construction, with completion estimated for early June. When completed, they will give the line a capacity of 145,000 bbl per day.

Station Additions Planned By Interprovincial Line

Designed to integrate pumping capacity with the expanded capacity of its looped line, Interprovincial Pipe Line Company's station expansion program for 1954 has reached contract stage. Mannix, Ltd., Calgary, will build an extension to the Regina station. Bird Construction, Ltd., Winnipeg and Calgary, has contracts for extensions at Glenavon, Sask., Cromer, Glenboro and Gretna, Manitoba.

Extensions will consist of a new engine room and pump room in each case, adjoining present fuel and store room, adding 112 ft to length of the existing station. Two new pumps and two engines will be installed in each station, with foundations added for a third unit. Horsepower of the new engines will be about double that of the original equipment, which comprises 1080 and 850 hp diesels running through speed increases to centrifugal pumps. Standard station equipment now includes four engines and pumps, of which one constitutes standby equipment.

One new station at Saxon, Wisconsin, on the 30-in. Lakehead pipe line between Superior and Sarnia, is to be built by R. C. Buck, Inc., of Superior, Wisconsin.

Missouri Valley Canadian, Ltd., Vancouver, has been awarded the contract for a 24-in. crossing of the South Saskatchewan River at Outlook, Saskatchewan, joining two 24-in. loop sections and supplementing the existing double 16-in. crossing. Completion date is scheduled for September.

WITH THE PIPE LINE CONTRACTORS

Lone Star Constructors, 10301 Shady Trail, Dallas, Texas, began work the middle of May on a 30-in. crossing of the Cimarron River, approximately 4 miles south of Englewood, Kansas, for Northern Natural Gas Company. H. A. "Red" Wylie is in charge with Joe Freeman the office manager.

Williams-Austin Company, 3322 Grant Building, Pittsburgh 19, Pennsylvania, has begun work on 48 miles of 24-in. for the Texas Eastern-Penn-Jersey Transmission Corporation. The section will start at Highway 522 near Mt. Union, Pennsylvania, and extend to the Susquehanna River near Duncannon, Pennsylvania. The warehouse and office are at Mt. Union. Ed Peters is general superintendent, Ralph Gaddy spread superintendent, and E. E. Mayes timekeeper.

Engineering-Construction Company, 402 North Cheyenne Avenue, Tulsa 6, Oklahoma, was scheduled to begin work June 1 on 90 miles of 16-in. line for Northern Natural Gas Company from Waterloo to Dubuque, Iowa. The superintendent is J. C. Williams, the office manager H. B. Hoge.

The city distribution system and lateral for Dallas, Georgia, consisting of 26 miles of 4-in. pipe, has been completed.

Western Pipe Line Constructors, Inc., Austin, Texas, began work in May on 45 miles of 26-in. pipe line for the Atlantic Seaboard Corporation. The line extends from Clendenin to Walkersville, West Virginia. The field office is at Gassaway; telephone 5401. W. B. Williams is superintendent.

A 45-mile, 24-in. line for Texas Eastern-Penn-Jersey Transmission Corporation also got underway in May. This line is from Lilly to Shirleyburg, Pennsylvania, with the field office at Martinsburg. Telephone: 275. K. K. Kelly is superintendent.

Oklahoma Pipe Line Constructors, 6612 Harry Hines Boulevard, Dallas, Texas, has contract for 60 miles of 12-in. takeup, recondition and relay for Montreal Pipe Line Company between Sutton and Montreal, Quebec. Work began late in May. Guy Craft is superintendent, Gene Gohring assistant superintendent, and Jack Brown office manager.

Parkhill Truck Company, P. O. Box 1856, Tulsa, Oklahoma, reports following:

Hauling, storing where necessary, and stringing approximately 303 miles of 12-in. pipe from West Memphis to Allen, Oklahoma, for Sunray Oil Corporation. Contractor, River Construction Corporation. Also approximately 97 miles of 10-in. pipe from Allen, Oklahoma, to Duncan, Oklahoma.

Hauling, unloading and racking approximately 50 miles of 24-in. for Texas Eastern Penn-Jersey Transmission Corporation from mill at Claymont, Delaware, to points in New Jersey and Pennsylvania.

Unloading from rail cars, hauling to, and stringing on pipe line right-of-way approximately 190 miles of 30-in. pipe for Northern Natural Gas Company, Sunray, Texas, to Ventura, Iowa. Contractor, Midwestern Constructors, Inc., Tulsa.

Unloading from rail cars and stockpiling 48 miles of 24-in. pipe for Texas Eastern Penn-Jersey Transmission Corporation, from A. O. Smith mill to points in Pennsylvania.

Hauling and stringing of approximately 89.7 miles of 16-in. pipe from Waterloo to Dubuque, Iowa, for Northern Natural Gas Company. Contractor, Engineering-Construction Company, Tulsa, Oklahoma.

Unloading from rail cars, stockpiling and later stringing approximately 18 miles of 16-in. pipe for Northern Gas Company at Farley, Iowa.

Hauling and stringing of approximately 71 miles of 16-in. pipe for Northern Natural Gas Company from Ogden to Dubuque, Iowa.

Hauling and stringing of approximately 48 miles of 24-in. pipe for Texas Eastern Penn-Jersey Transmission Corporation from a point near Mount Union, Pennsylvania, to a point near Duncannon, Pennsylvania. Contractor, Williams-Austin Company, Pittsburgh, Pennsylvania.

Associated Pipe Line Contractors, Inc., Houston, Texas, is working on 175 miles of 10-in. line from Bozeman, Montana, to Clinton, Montana, for Yellowstone Pipe Line Company. Jim Ed Andrews is superintendent and Buck Johnson office manager at the Helena field office.

R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, was the successful bidder on construction of approximately 105 miles of 8-in. line between Alexandria, Minnesota, and Fargo, North Dakota, for the Great Lakes Pipe Line Company. Work began the middle of May.

This extension, which parallels an existing 6-in. line, will provide additional capacity to the company's delivery terminal at Fargo and make possible increased use of the 6-in. line for moving products to the Grand Forks, North Dakota terminal.

Capacity of the Alexandria terminal will be enlarged this summer by a 12-in. line, which will be laid from a junction with other company lines near Rosemount, south of Minneapolis, westward to Willmar, Minnesota, and from there along the route of the present 8-in. line to Alexandria.

The company also is laying 133 miles of 26-in. loop line in two sections of Lakehead Pipe Line Company, one a 75-mile section, the other 58 miles. A. A. Carrigan is superintendent at Gonvick, Minnesota, and Jim Magill at Cloquet, Minnesota.

Northern Natural Gas Company has let a contract for 74 miles of 20-in. in Iowa and South Dakota.

Eastern Pipe Line Contractors, 1801 Mercantile Bank Building, Dallas, Texas, had only 20 miles left to lay on the Yellowstone Pipe Line System (May 18), and was getting ready to go over Thompson Pass, a considerable engineering undertaking. The company originally had a total of 158 miles in two sections. The first section was completed sometime ago. The pipe is 10 in. Field headquarters are at Thompson Falls, Montana. A. L. "Bull" Stewart is superintendent and J. W. "Dub" Arthur office manager.

Anderson Brothers Corporation, P. O. Box 2591, Houston, Texas, has contract for 51 miles of 26-in. loop for Lakehead Pipe Line Company between Grand Rapids and Bemidji, Minnesota. Work will begin when weather and ground condition permits. R. L. Leonard is superintendent.

Fulton Banister Construction Company, 409 Northern Hardware Building, Edmonton, Alberta, is working on 124 miles of 24-in. loop for Interprovincial Pipe Line between Alberta-Saskatchewan border and west bank of South Saskatchewan River. The field office is at Rosetown, Sasketchewan, with Jerry Nash superintendent.

Mannix, Ltd., Calgary, Alberta, is working on 129 miles of 24-in. loop for Interprovincial Pipe Line between Edmonton and Alberta-Saskatchewan border. The kick-off was May 15. C. P. Baker is project manager, "Sandy" Day project engineer, P. Swityk office manager, and G. Lyon general superintendent. The field office is at Provost, Alberta.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, has contract for 189.2 miles of 30-in. for Northern Natural Gas Company, in 11 loops. One spread is working out of Ashland, Kansas, on 94.3 miles in 5 loops, one in Texas, one in Oklahoma, and three in Kansas, with M. T. Wilhite, superintendent; John Work, spreadman, and N. O. Boies, office manager. Other spread is working on 94.9 miles in six loops, one in Kansas, one in Nebraska, three in Iowa, and one in Minnesota. Spreadman is Denver L. Franklin, office manager is Bernie Seagle, and Wilhite is superintendent.

Company also has contract to dismantle pumping station at Alemeda, Texas, move building and equipment and construct new station at Adena, Colorado, for Pawnee Pipe Line Company. Eldon Rolfe is superintendent of this job.

Company also has contract to construct pump station at Fergus Falls, Minnesota, for Standard Oil Company. Charles Malone is superintendent and Frank Conway is office manager.

Foster Wheeler Corporation, 165 Broadway, New York 6. New York, has contract with North Atlantic Treaty Organization for management of 1920 miles of product line to be laid in Western Europe.

Houston Contracting Company, Ltd., 2707 Ferndale Place, Houston, Texas, has the following construction work:

Approximately 500 miles of 30-in. natural gas line for Gulf Interstate Gas Company from Rayne, Louisiana, to Kinkade, Tennessee. 370 miles have been completed and the remaining 130 miles will be handled as follows:

From New Albany, Mississippi, going north, E. C. Norris, superintendent; R. E. Thornton, assistant superintendent; R. J. Axsom, office manager; headquarters, New Albany, Mississippi. Pipe laying under way.

From Kinkade, Tennessee, going south, W. H. Hayes is superintendent; M. L. Thompson, assistant superintendent; J. B. Stoddard, office manager; headquarters Hohenwald, Tennessee. Work to start as soon as weather and ground conditions permit. Pipe laying under way.

Approximately 65 miles of 12-in. products line for Shell Pipe Line Corporation from Baton Rouge, Louisiana, to Norco refinery near New Orleans. H. J. Muckley is superintendent, H. L. Leake spread superintendent, and G. A. Warner, office manager. Field headquarters are at Baton Rouge. Pipe laying began in May.

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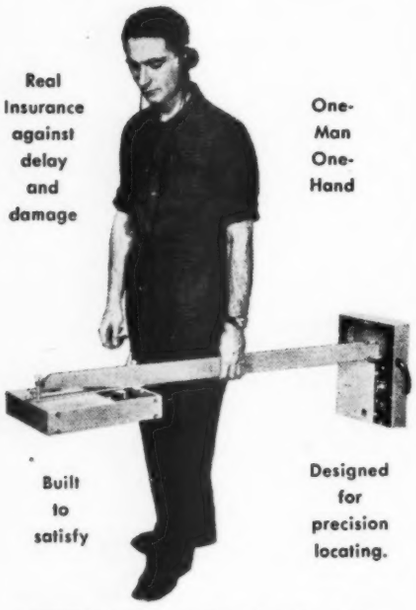
THE WILKINSON LINE LOCATOR

will substitute *facts* for guesses and map errors



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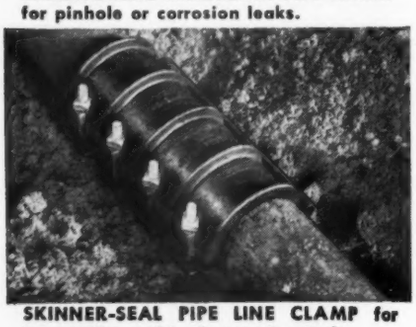
ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.



SKINNER-SEAL PIPE LINE CLAMP for long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY

SOUTH BEND 21, INDIANA, U. S. A.

Contractors

Anderson International Contractors, Edmonton, Alberta, has contract for 201 miles of 24-in. line for Interprovincial Pipe Line Company in two sections, including one section of 101 miles between east bank of South Saskatchewan River and Regina, and another 100 miles between Regina, Saskatchewan, and Gretna, Manitoba. Whitey Gould is superintendent of spread work on 101 mile section, out of Regina field office, and Buster Watson is superintendent of other spread with headquarters in Gretna. R. W. Dick Jernigan will be in charge of over-all project. Pipe work began June 1.

Dunn Brothers, 801 Mercantile Building, Dallas, Texas, has reported the following hauling, stringing and unloading jobs:

335 miles of 30-in. for Gulf Interstate Gas Company between Kinkade, Tennessee, and Kenova, West Virginia. Prime contractor is H. C. Price Company.

140 miles of 30-in. for Tennessee Gas Transmission Company between Savannah, Tennessee, and the Tennessee-Kentucky state line.

62 miles of 30-in. for Tennessee Gas Transmission Company between Lisbon and Cambridge, Ohio.

Various sizes for El Paso Natural Gas Company in the Farmington, New Mexico area. El Paso is doing own construction.

208 miles of 20-in. for Magnolia Pipe Line Company, Corsicana to Beaumont, Texas. Prime contractor is H. B. Zachry Company.

49 miles of 12-in. for El Paso Natural Gas Company, Farmington, New Mexico, to Rankin, Texas.

54 miles of 24-in. in Pennsylvania for Texas Eastern Penn-Jersey Transmission Company. Prime contractor is H. C. Price Company.

60 miles of 10¾-in. in Iowa for Northern Natural Gas Company. Prime contractor is G. G. Griffis Company.

57 miles of 30-in. in West Virginia for United Fuel Gas Company. Prime contractor is H. C. Price Company.

Williams Brothers Company, 324 National Bank of Tulsa Building, Tulsa, Oklahoma, has contract for 615 miles of 8-in. products line in Alaska for the U. S. Corps of Engineers in a joint venture with McLaughlin, Inc., and Marwell Construction Company.

Right-of-way work began in May on 110 miles of 18-in. for Southern Natural Gas Company in Alabama and Georgia. The field office is at Uniontown, Alabama. "Red" Graves is superintendent, and "Buddy" Graves division superintendent.

Company also has contract for 20 miles of 34-in. line for Creole Petroleum Company in Venezuela. Marvin Jones is superintendent.

Missouri Valley Dredging Company, 222 William Street, Omaha 8, Nebraska, will begin work soon on two 24-in. line across the Mississippi River near Greenville, Mississippi, for Trunkline Gas Company. Harold Hubbard will be superintendent and George Van Horn office manager.

Two lines will be laid under the Schuylkill River near Reading, Pennsylvania, for Texas Eastern Penn-Jersey Transmission Corporation. These will consist of a 16 and a 24-in. line. Eldon Sumrall will be in charge with R. O. Whitford the office manager. For the same company a 16 and a 24-in. line will be laid across the Delaware River near Lambertville, New Jersey. The same men will be in charge.

H. B. Zachry Company, Transit-Tower, San Antonio, Texas, has contract for 208 miles of 20-in. for Magnolia Pipe Line Company between Corsicana and Beaumont, Texas. Work is underway. About 112 miles of pipe to be used is being coated by C-R-C Engineering Company, Houston, and Mayes Brothers, Inc., Houston.

D. B. Shrum is in charge of the spread working out of Fairfield, Texas. A second field office is at Kountz, Texas, with W. L. Huff superintendent and Roy Shields assistant superintendent.

Olson Construction Company, Lincoln, Nebraska, has been awarded the general contract for construction of a delivery terminal at Doniphan, Nebraska, for the Great Lakes Pipe Line Company. Equipment has been moved onto the job.

Doniphan terminal will be supplied by a 132-mile 8-in. line that is being laid from Nebraska City as a lateral extension of the Great Lakes' system.

First deliveries of refined products from the new terminal are scheduled to be made by late summer. All phases of construction will be completed in November.

H. C. Price Company, Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, is constructing 346 miles of 30-in. high pressure natural gas pipe line for Gulf Interstate Gas Company, starting at a point near Gordonsburg, Tennessee, and extending in a northeasterly direction to a point near Catlettsburg, Kentucky. There are 276 miles completed and 70 miles remaining to be completed (May 10).

The company also has a contract covering construction of 57 miles of 30-in. gas pipe line for United Fuel Gas Company starting at the Big Sandy River, south of Catlettsburg, Kentucky, and extending in an easterly direction to a point about 6 miles northwest of Charleston, West Virginia.

Approximately 54 miles of 24-in. natural gas line will be laid for Texas Eastern Penn-Jersey Transmission Corporation, starting at a point near Delmont, Pennsylvania, a few miles east of Pittsburgh, and extending eastward to a point on the east side of state highway 53, approximately 1½ miles northeast of Lilly, Pennsylvania.

Engineers Limited Pipeline Company, 225 Bush Street, San Francisco, California has 109 miles of 34-in. line for Pacific Gas and Electric in two loops, one 79 mile section between Newberry and Danby, California, and a 30-mile section from San Martin to Tres Pinos, California.

Company also has 81 miles of 10-in. line for Yellowstone Pipe Line Company between Murray, Idaho, and Spokane, Washington. C. P. Hamilton is superintendent and Virgil Darby, office manager.

Anderson Brothers of Colombia, 704 Prudential Building, Houston, Texas, has 60 miles of 8-in. products line for Empresa Colombiana de Petroleos. Rusty Killingsworth is superintendent on the South American job.

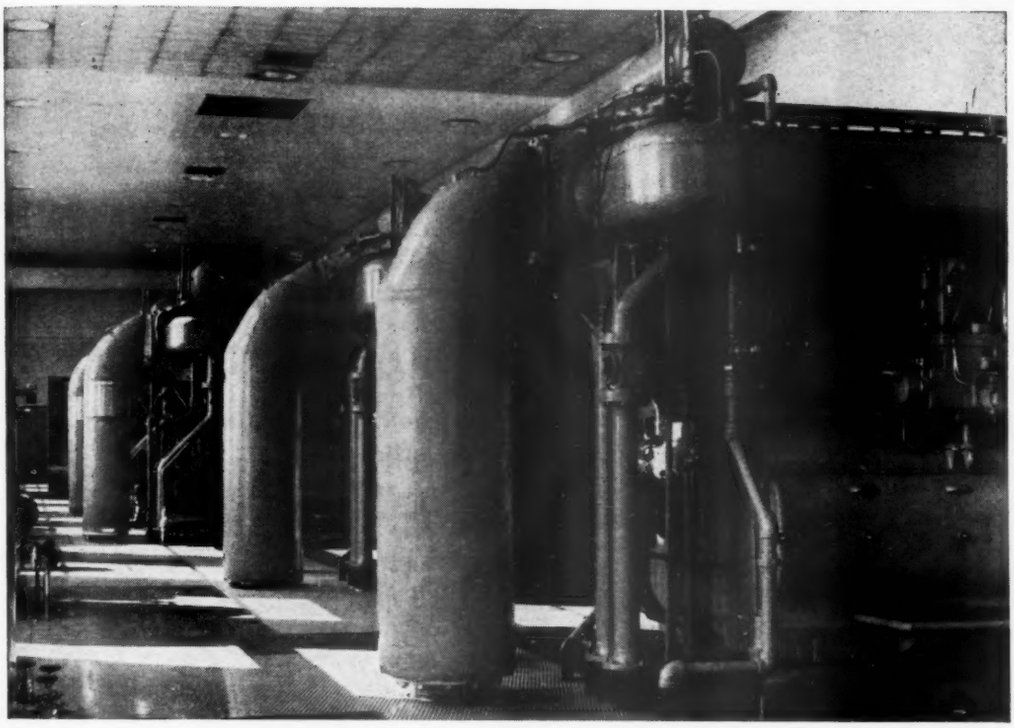
Company also has 30,000 ft of 8 and 16-in. line in Lake Mararcaibo, Venezuela, for Shell Oil Company. Earl Saulsman is superintendent.

Collins Construction Company, Victoria, Texas, has contracted from Merritt-Chapman and Scott of India for construction of 84,000 ft of submarine line in the harbor of Bombay, India.

Another Pipe Line Company Reports

2 to 3 times more horsepower hours

• • • after installing Koppers Conformable Oil Rings



Koppers Porous Chrome* Rings. Porous chrome surface holds and distributes oil during break-in. Seats quickly. This chrome prevents grit from embedding in ring surface. Prevents cylinder wall scratching. Reduces wear 50%. Last 4 times longer than other rings.

Koppers Conformable Ring maintains constant unit pressure for positive oil control. Conforms readily to meet cylinder distortion because flexible cast iron member is pressed outward by abutment type spring which exerts uniform radial pressure around entire circumference.

*Van der Horst Process

Here's proof that Koppers Piston Rings increase operating efficiency.

Prior to using Koppers Conformable Oil Rings, a pipe line company reported average oil consumption as approximately 3500 to 4000 horsepower hours per gallon. Now they are getting 2 to 3 times that much.

In addition to this large saving in oil consumption, they find they get longer periods of satisfactory operation between overhauls.

As a result, this pipe line company has adopted Koppers Piston Rings as standard equipment on all their 12½" x 13" turbo-charged engines.

Does this suggest possible savings in your operation? Less oil consumption? Less down time, lower labor costs? Then investigate Koppers Porous Chrome* and Conformable Oil Rings. And install them next time you have a piston ring replacement job.

Write for special assistance from our experienced technical staff. No obligation, of course .... and mail the coupon for special conformable ring folder.

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Company----------

Address----------

City----------Zone-------State----------

PERSONALS

A. J. Wisdom, assistant right of way superintendent for Service Pipe Line Company, has retired after 18 years service with that firm and 31 years experience

A. J. Wisdom

in the field of acquiring right of way. Wisdom supervised right of way buying for Service's new Tioga-Mandan large diameter crude line in North Dakota. A native of Missouri, Wisdom became interested in the petroleum industry after World War I and has been actively engaged in some phase of it since.

Walter O. Allen, United Gas Pipe Line construction superintendent, has been named assistant district manager of the company's San Antonio district. Allen, a native Texas, has been with United Gas since 1923.

Joseph W. Meehan has been elected president of Pure Transportation Company, wholly owned subsidiary of Pure Oil Company. In addition to his new duties, Meehan will continue as general manager of pipe lines and Pure's crude oil purchasing division.

Michael L. McGannon has been promoted from district superintendent to assistant division superintendent at Humble Pipe Line's Longview, Texas, office. **Ed R. Neath** has been named Longview district superintendent and **A. M. Brock** has been named district superintendent at Mexia, Texas, replacing Neath, who formerly held that post.

W. H. Stewart, Sun Pipe Line Company, Beaumont, Texas, has been named chairman of the NACE Technical Practices Committee T-2 on Pipe Line Corrosion. Other NACE committee chairmen named include T-1, Corrosion of Oil and Gas Well Equipment, **E. C. Greco,** United Gas Corporation, Shreveport; T-3, General Corrosion, **F. M. Watkins,** Sinclair Research Laboratories, Harvey, Ill.; T-4, Utilities, **F. E. Kulman,** Consolidated Edison Company of New York; T-5, Corrosion Problems in Process Industries, **Paul J. Gegner,** Columbia-Southern Chemical Corporation, Barberton, Ohio; and T-6, Protective Coatings, **A. J. Liebman,** Pitmar Centrifugal Machine Corporation, Pittsburgh.

James W. Carneal has been appointed assistant superintendent of Texas Gas Transmission Corporation's pipe line department. He was formerly assistant to the superintendent of the department.

Karl T. Feldman, Sinclair Pipe Line Company, has been elected a director of the company and appointed director of engineering. Feldman, formerly chief engineer, will coordinate activities of the electrical engineering department, supervised by **Glenn L. Ladd,** and general engineering, supervised by **Paul D. Fell,** who succeeded Feldman as chief engineer.

J. L. Creed, general superintendent for the Portland-Montreal Pipe Line for 12 years and recently consultant for the company, has retired. Creed spent 28 years with Standard Oil Company of Louisiana before joining Portland-Montreal.

L. W. Ewing, Jr., has been named superintendent of product movement for Standard Oil Company of Indiana's products pipe lines. He was formerly assistant chief engineer.

Charles LeNoir has been named executive vice president of Western Pipe Line Constructors, Inc., Austin, Texas. **E. G. Morrison,** formerly secretary, has been named vice president and **George M. Marsh** is the firm's new secretary-treasurer.

Harrington A. Rose, gas engineer for Stone and Webster Service Corporation has been named secretary of the general management section of American Gas Association. **Bruce A. McCandless** has relinquished the post of acting secretary of the general management section to devote full time to his administrative duties as assistant to the managing director.

General management, newest section in AGA, was formed early last year to include other committees.

Richard P. Shuck has been appointed supervisor of oil movements for The Ohio Oil Company, Pipe Line Department. Shuck, who has been pipe line accounting

R. P. Shuck

department supervisor, assumes the newly established position June 1. In this capacity, he will co-ordinate the movement of both crude oil and petroleum products through the company's pipe line transportation system. His duties will include working with shippers and connecting carriers.

J. D. McConnell, Sinclair Pipe Line general manager of crude lines, has been elected director of the Goodall Pipe Line Company.

H. E. Freeman has been named chief gager for Sun Pipe Line Company at Beaumont, Texas. He was formerly foreman at Meraux, Louisiana.

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CRUDE LINES

PRODUCT LINES

NATURAL GAS LINES

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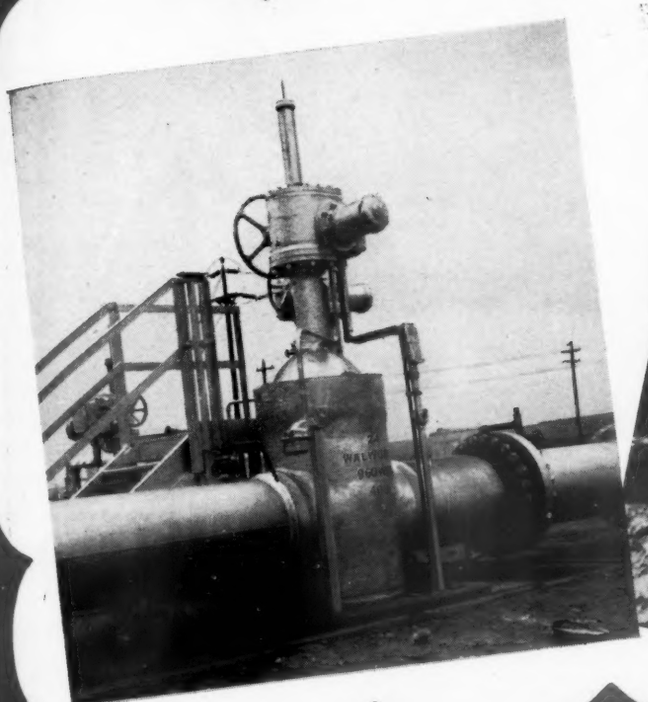
2 Questions

WITH THE SAME ANSWER



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Gates or Lubricated Plugs?

Walworth engineers work directly with pipeline engineers and operators—suggesting valves for all types of pipeline installations. They're quick to recognize a condition where a quick-opening lubricated plug valve is best employed—or, one where a gate valve will be better for a particular requirement. Whenever you are faced with the problem of selecting proper pipeline valves—call Walworth.

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From Walworth — because Walworth makes *both* gate valves and lubricated plug valves. That's why Walworth's recommendations will be unbiased. And there is a Walworth representative or distributor near you. They are situated in principal centers throughout the world. Write, phone, or wire for further details.

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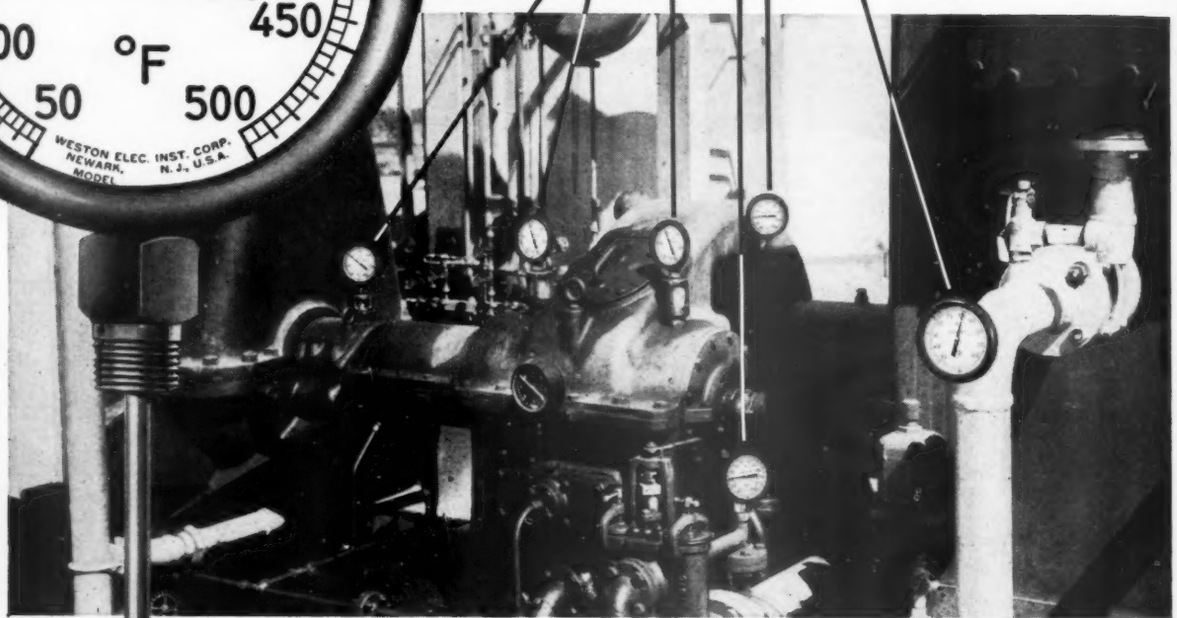

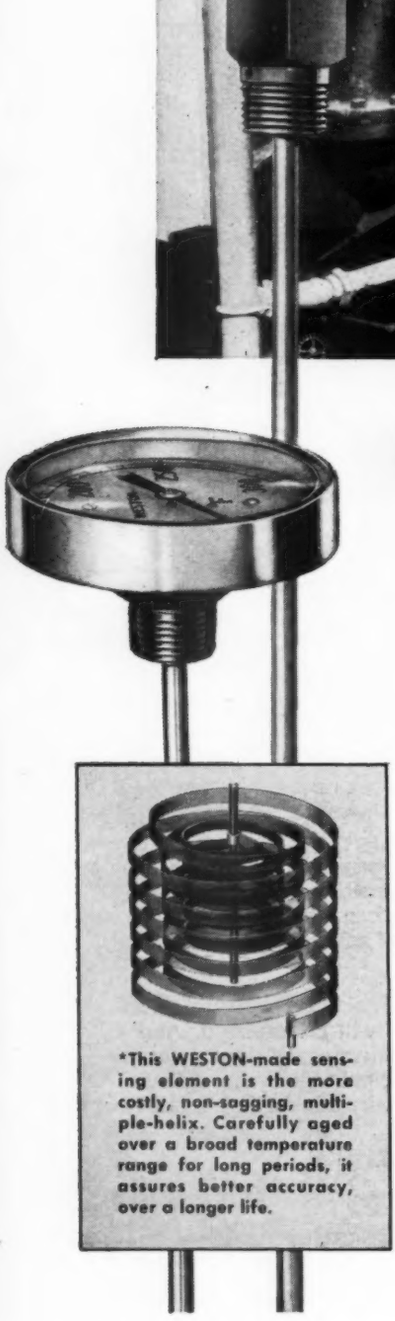

*This WESTON-made sensing element is the more costly, non-sagging, multiple-helix. Carefully aged over a broad temperature range for long periods, it assures better accuracy, over a longer life.

WESTON *all-metal* THERMOMETERS

(with Multiple Helix)*

Here's another typical example of how large processing plants have solved temperature checking problems, and cut thermometer costs besides. With a WESTON dial-type thermometer at every checkpoint, temperatures are read at a glance . . . in far less time, and with far greater accuracy. Their sturdy all-metal construction resists breakage, gives them far longer life on operating equipment. And the exclusive WESTON multiple helix employed assures dependable accuracy during all this long life.

Available in a broad selection of types, sizes, ranges and stem lengths, WESTON thermometers are today standard on all types of mobile and stationary equipment and machines, large and small; as well as on piping, conduit, ducts, etc. Ask your distributor, or local WESTON representative for complete information, or write for descriptive bulletin . . . WESTON Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON 5537 *Thermometers*

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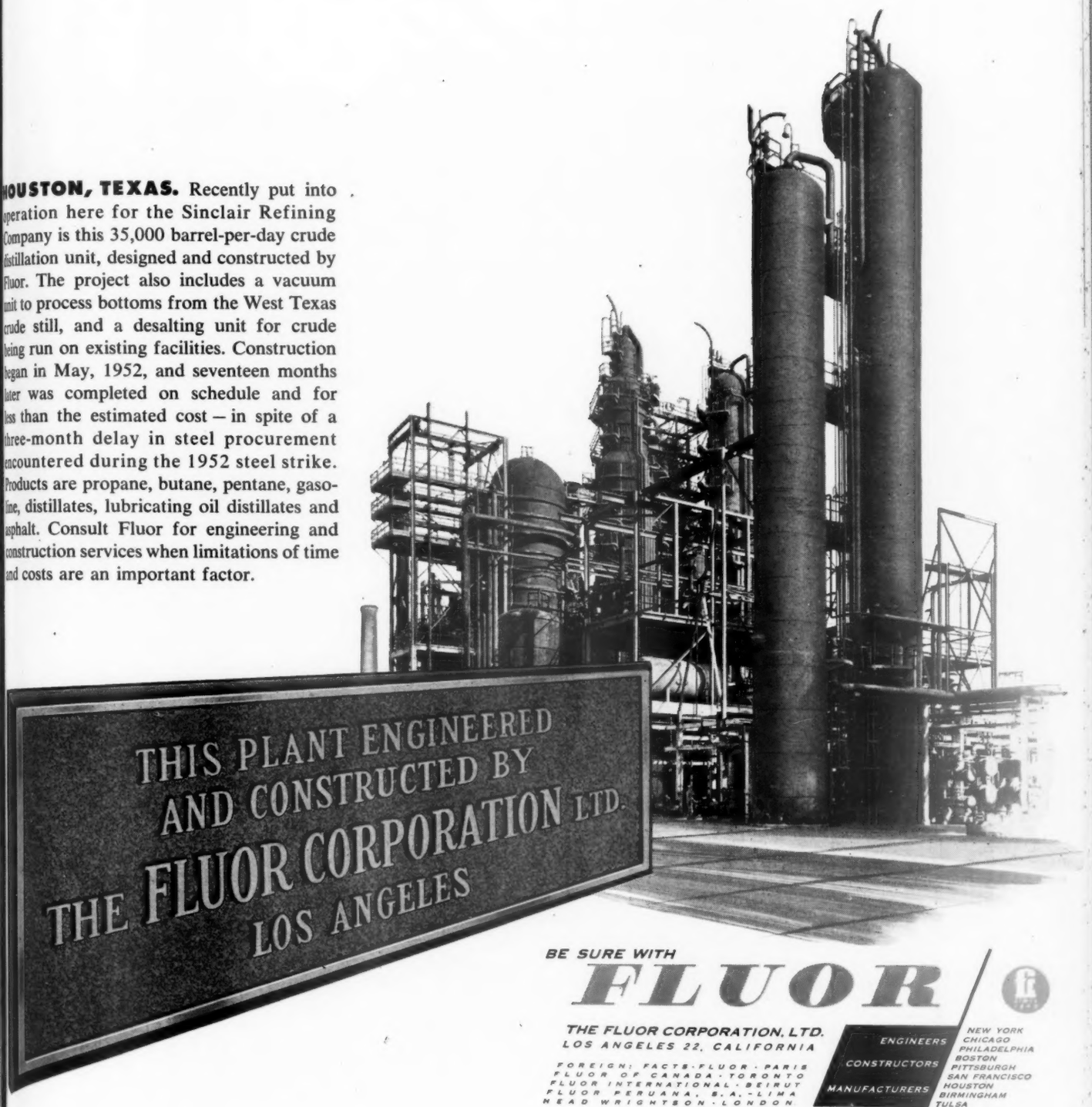
HOUSTON, TEXAS. Recently put into operation here for the Sinclair Refining Company is this 35,000 barrel-per-day crude distillation unit, designed and constructed by Fluor. The project also includes a vacuum unit to process bottoms from the West Texas crude still, and a desalting unit for crude being run on existing facilities. Construction began in May, 1952, and seventeen months later was completed on schedule and for less than the estimated cost – in spite of a three-month delay in steel procurement encountered during the 1952 steel strike. Products are propane, butane, pentane, gasoline, distillates, lubricating oil distillates and asphalt. Consult Fluor for engineering and construction services when limitations of time and costs are an important factor.



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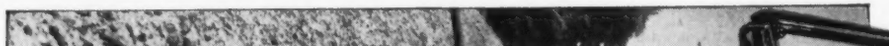
PHYSICAL CONSTANTS OF HYDROCARBONS

Hydrocarbon	Specific gravity 20/4 °C.	M. P. °C.	B. P. °C.	Index of refraction n_D^{20}	Viscosity Abs. Poises	Spec. heat	Heat of vaporization Cal/G	Heat of combustion K-Cal/mol.	Aniline point °C.	Coeff of expansion °C.	Critical constants P Atms.	Critical constants T °C.	Critical constants D	Vapor pressure °C.	Vapor pressure mm.	Octane number Actual	Octane number Blending	Surface tension 20°C. Flash °C.
C_2H_4 Ethylene (ethene)	0.9852 (air) / 0.5699 (-103.9)	−169.4	−103.9 (767.5)	1.363 (-100)	0.000093°(g) / 0.0000990 (17.1)	0.371(g) (26.8)	118.5	337.28p		0.006894 (-17.8)	50.9	9.8	0.22	−125.2 / −110.0	174.0 / 523.4	>100r / 81.0m	85.5r	16.50 (-103.9)
C_3H_6 Propylene (propene)	1.49 (air) / 0.5148	−185.2	−47.6	1.3567 (-40)	0.000078°(g) / 0.0000840	0.371(g) (26.17)	108.8	491.82p		0.002718 ($-17.8+10$)	45.4	91.4	0.233	−85.02 / −60.60	75.7 / 404.6	>100r / 85m	102r	16.70 (-47.0)
C_4H_8 1-Butene	1.93 (air) / 0.5952	−190	− 6.32	1.3777 (-25)	0.000070°(g) / 0.00008194 (0)	0.366(g) (20–140)	93.8	649.66p		0.002052 (20–30)	42.1	160.0		−28.07 / −16.69 / − 1.92	300 / 500 / 900	80m	111.5r	15.9 (-6.1)
2-Butene*	2.004 (air) / 0.6300 (1.0)	−127.0	1.0		0.000069°(g) / 0.00007964 (0)	0.366(g) (20–140)	96.3	638.2		0.002037 (20–30)	42.1	155.0		−19.2 / − 4.7	334.7 / 609.8	83m		16.7 (1.0)
2-Methyl-propene (isobutene)	2.011 (air) / 0.5942	−140.7	− 6.93	1.3796 (-25)	0.000073°(g) / 0.00008434 (0)	0.366(g) (20–140)	93.8	647.2p	14.9	0.001954 (20–30)	39.48	144.7	0.234	−28.52 / −17.19 / − 2.50	300 / 500 / 900	87m		15.72 (-6.6)
C_5H_{10} 1-Pentene (amylene)	2.42 (air) / 0.6410	−138.0	30.1	1.3710	0.00239 (20)	0.282c	75.0 (12.5)	806.78p	19.0		40.4	201.2				92r	98.5r	
2-Pentene*	2.42 (air) / 0.6505	−138.0	36.4	1.3797		0.515 (16)		794.5	18.3		40.4	202.4				98r / 80m	125r / 107m	16.93
2-Methyl-2-Butene (Trimethyl-ethylene	2.42 (air) / 0.6620	−133.6	38.49	1.3869	0.00252c / 0.00230 (10)	0.508 (16)	93.1	795.7p	12.8	0.00158 (15–20)	35.3	191.6		2.5 / 18.1	184.7 / 359.1	98r	157r / 122m	17.34
C_6H_{12} 1-Hexene	2.902 (air) / 0.67337	−141.0	63.7	1.3880	0.002885 (−20)	0.499 (22.4)	82.54	963.9p	22.8			243.5		10 / 60	90 / 600	80r	85r	17.77
2-Hexene*	0.6813	−149.0	67.9–68.1	1.3928	0.00314 (20)		84.33	962.3p	26.0			243.8		0 / 60	50 / 600	89r / 78m	100r	18.93
3-Hexene	0.68161 (19)		66.6 / 67.0	1.3942	0.00335 (20)		84.87	950.8	27.0 (cst)							97r		19.48
2-Methyl-1-Pentene	0.6817		61.5–62.0	1.3921				950.8									69.5m	

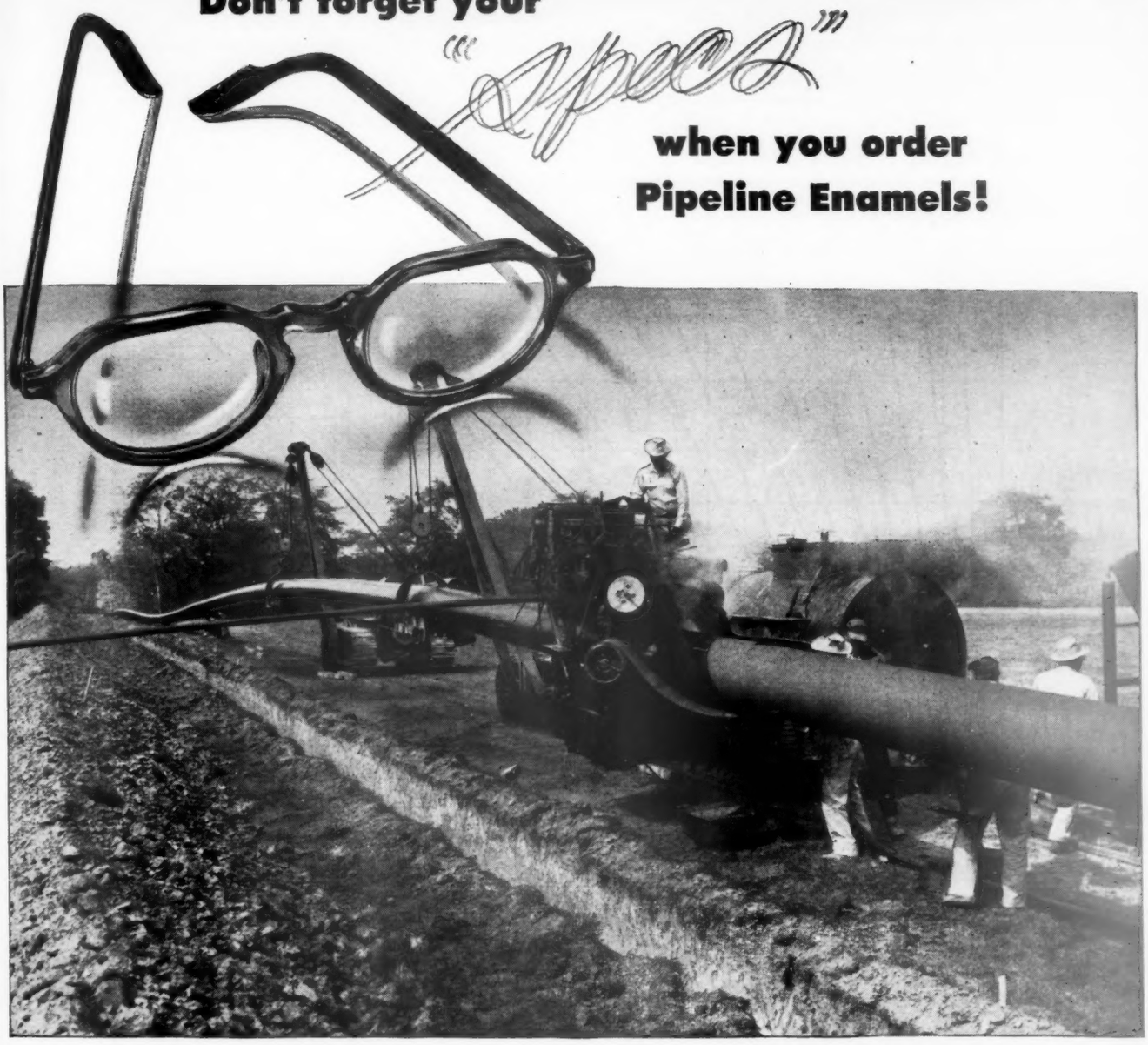
See table P 771.001. B for footnotes.

Table from "Physical Constants of the Principal Hydrocarbons," by M. P. Doss, 4th edition, by courtesy of copyright owner, The Texas Company.

XUM



Don't forget your "Specs" when you order Pipeline Enamels!



"Specs" are the yardstick of quality for almost any industrial product you buy these days. Then why shouldn't you buy pipeline enamels by written specification, too? Why should you be in the dark about penetration, ash, softening point and all the other specifications that insure an enamel's performance and protection characteristics?

For many years, Pittsburgh Coke & Chemical has published the specifications of *Pitt Chem* Modified Enamel. We invite you to compare our "Specs" to samples from any drum of *Pitt Chem* Enamel you buy. We'd like you to prove to yourself that coal-to-enamel quality control can provide you with made-to-specification pipeline enamels that perform better on application and protect years longer in service. ● Write today for booklet describing *Pitt Chem* Modified Pipeline Enamel specification limits and their importance to you.

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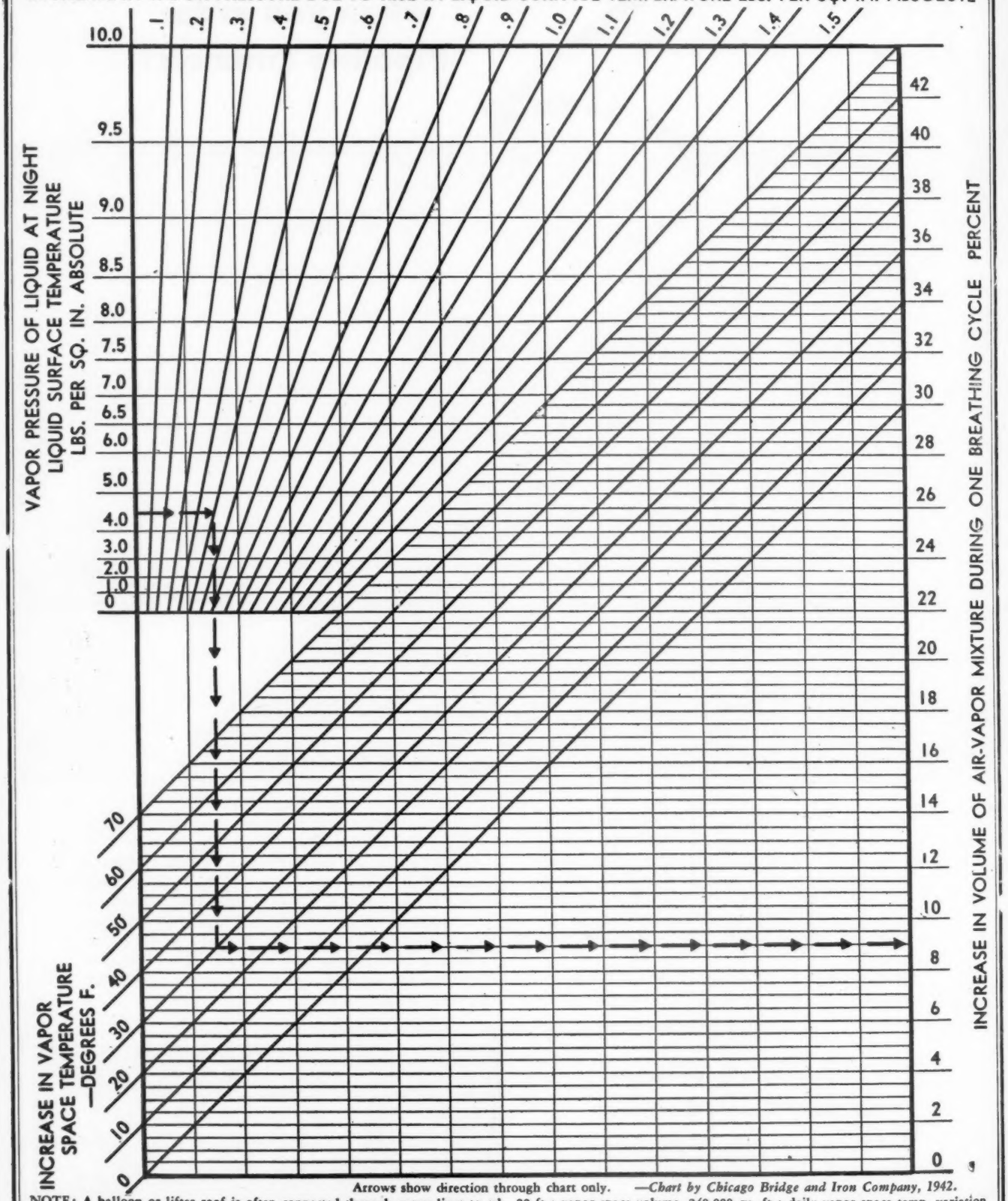
XUM

EXPANSION OF AIR-VAPOR MIXTURES IN ATMOSPHERIC STORAGE TANKS



Arrows show direction through chart only. —*Chart by Chicago Bridge and Iron Company, 1942.*

NOTE: A balloon or lifter roof is often connected through vapor lines to adjacent tanks with cone roofs, serving as a gasholder for the group of tanks. It is then necessary to estimate the probable expansion of the air-vapor mixture in all of the tanks under maximum temp. conditions to determine the volume of gasholder capacity required. This may be done by calculating each separately and totaling. *Example:* Find the volumetric expansion of the air-vapor mixture in an 80,000-bbl. storage tank if the product stored is 10 lb. R.V.P. gasoline; outage 20 ft.; vapor space volume, 240,000 cu. ft.; daily vapor space temp. variation, 40°F.; day liquid surface temp., 75°F.; and night liquid surface temp., 70°F. From Table P 640.1 vapor pressure at 75°F. is 6.9 lb. per sq. in. abs. and at 70°F. is 6.3 lb. per sq. in. abs. The increase in vapor pressure is 0.6 lb. Enter the above chart from the left at 6.3 lb., across to 0.6 lb. increase, down to 40° vapor space temp. variation, and then across to the right to the estimated expansion of 12.7 percent. The total expansion is 240,000 × 0.127 = 30,500 cu. ft.

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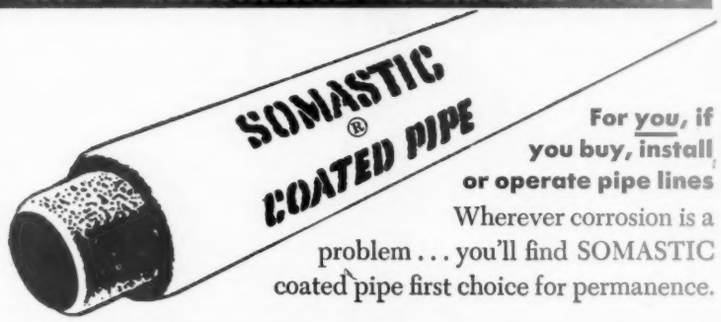

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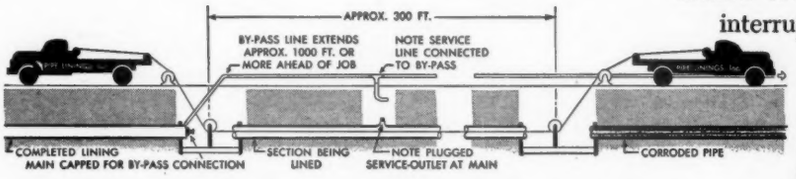
2

THE TATE PROCESS, applicable to water, oil and gas pipe lines, renews old iron and steel pipe "in place" as shown here in the schematic drawing. The Tate Process is used for pipe lines from 4" to 16" in diameter. Only momentary interruption to service is necessary while by-pass sections are installed.


APPROX. 300 FT.
BY-PASS LINE EXTENDS APPROX. 1000 FT. OR MORE AHEAD OF JOB
NOTE SERVICE LINE CONNECTED TO BY-PASS
COMPLETED LINING MAIN CAPPED FOR BY-PASS CONNECTION
SECTION BEING LINED
NOTE PLUGGED SERVICE-OUTLET AT MAIN
CORRODED PIPE

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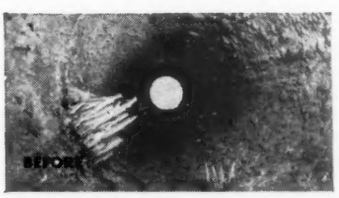
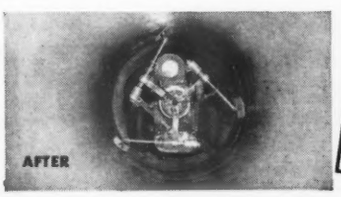
3

THE CENTRILINE PROCESS is used for lining 16" to 144" pipe lines "in place." Cost is much less than the cost of installing new pipe. Premixed cement-mortar is thrown by centrifugal force, at uniform high velocity, against the inside surface of the pipe, and then mechanically troweled to a smooth, even finish. Centrilining is applicable to fresh or salt water, oil, sewage, gas or industrial waste lines, sewers and drains.





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- Protects against corrosion, contamination and discoloration at much less than the cost of installing new pipe!

Complete mobile equipment and expert crews are available to bring new efficiency to your old pipe. A Pipe Linings, Inc. hydraulic engineer will be glad to discuss your problem. No obligation!

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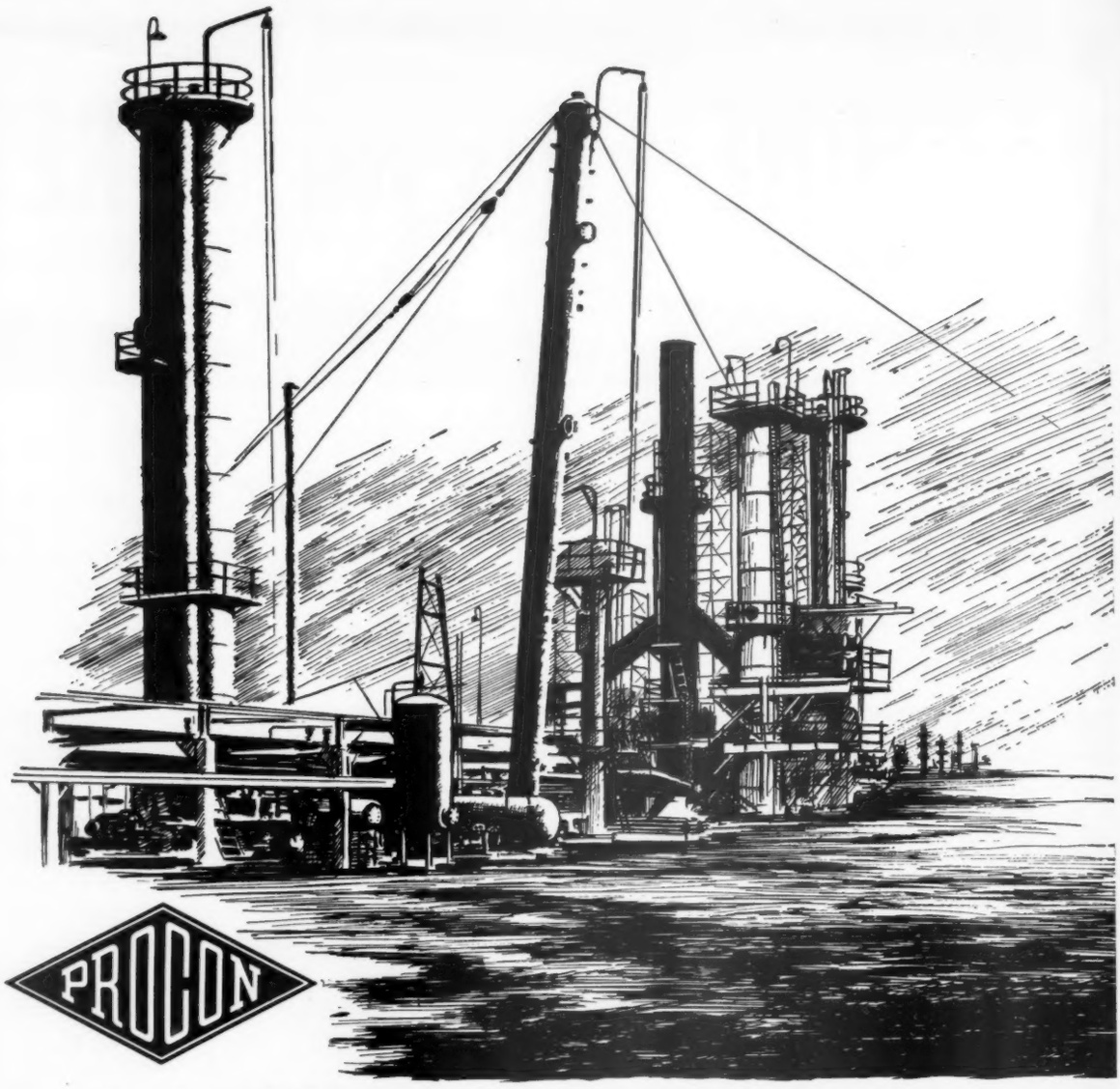

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To obtain more information on products advertised see page E-61

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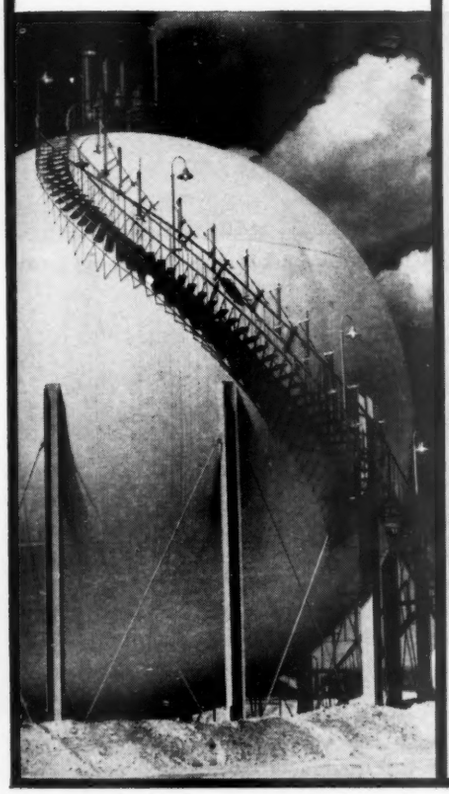

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In its flush period wells were completed in El Dorado field with potentials up to 20,000 bbl a day.

El Dorado Field Was Classroom for

J. P. STEEPER and A. E. STRAUB

This one field provided more oil than any other to the Allied Forces in World War I — the discovery well of 38 years ago produces 18 to 20 bbl of oil a day

IN the roll call of Kansas oil fields, the Cities Service-discovered El Dorado field of Butler County stands out as the most prolific in the Sunflower State — the result of pioneering geological work and development progress in the field of drilling and production engineering.

Although oil riches near El Dorado had been foretold by an itinerant seer at the turn of the century, the location of the Stapleton No. 1 discovery September 1, 1915, was on a structure outlined by Cities Service geologists who made the first wide-area geological survey in the history of oil.

The accuracy of this "first" in geological prospecting is evidenced in the writings of A. E. Fath of the Kansas State Geological Survey (printed in 1921):

". . . of the 34 square miles of territory which the company's geologists, from their survey of surface rocks prior to the drilling of the discovery well outlined as most promising in the main part of the field . . . only seven square miles have since proven barren of oil. Outside of this area outlined as most promising, only 3.5 square miles have since proven productive. With this advance information, the company was able to acquire about two thirds of the territory that has since proven productive, and through these large holdings it has been by far the leading producer in the field."

Out of that first wide-area geological survey, which spanned the eastern half of the state, came the outlines of many of today's East Kansas fields. The Cities Service-discovered Augusta oil field, Kansas' first major oil discovery, is but one of the few monuments to this pioneering effort. Others are the productive Scully and Loomis areas of Butler County and the Ramsey and Douglas fields.

Based on the results of surface geology, Cities Service located its Stapleton No. 1 test, 660 ft from the north line and 660 ft from the east line of the SE/4, Sec. 29, T24s, R.5e, Butler County. The well was spudded on September 29, 1915. First show of oil was in the 660-ft sandstone. While other drilling machines punched holes down to the 660-ft sand, the Stapleton discovery continued drilling in search of deeper producing zones. It found 9 shows of oil and gas, ranging from

The Authors

J. P. Steeper joined Cities Service as a member of the Junior Engineer Training School in 1946. He has a petroleum engineering degree from the University of Oklahoma and, after completing the J. E. course, joined the Oil Production Division as office engineer. He was named special engineer, Natural Gas Division, in 1949 and in 1951 was appointed administrative assistant in the Oil Production Division of Bartlesville, Oklahoma.

After graduating from the Missouri School of Mines with a degree in petroleum engineering A. E. Straub joined Cities Service Company in 1940. He was a lease mechanic at Oklahoma City and Seminole and a roustabout and engineer at Seminole. He served as engineer at Odessa, Texas, and in 1949 was transferred to Bartlesville as assistant chief engineer, Oil Production Division.

When gas supply dwindled in 1918 Cities Service began electrification of drilling, pumping and other operations.

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Advanced Teaching of Oil Technology

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549 to 1560 ft. The Viola lime was penetrated from 2445 to 2465 ft, and when drilling the Simpson zone from 2465 to 2503 ft the hole filled with live oil. It was deepened to 2511 ft where water was encountered and plugged back to 2500 ft with lead wool. On February 6, 1916, Stapleton No. 1 showed a potential 110 bbl of oil daily.

Production Climbs

Phenomenal success in the development of the El Dorado field and the nearby Augusta pool was largely responsible for an increase in Kansas production from less than 3,000,000 bbl of oil in 1915 to 36,500,000 bbl in 1917, advancing Kansas from sixth to third rank in petroleum-producing states. In 1917, a total of almost 1000 oil and 28 gas wells were completed in Butler County, for a per well average of 291 bbl of oil daily. Most of this activity centered in the El Dorado field, where a number of Ordovician wells were completed with potentials up to 20,000 bbl per day.

For several years after its discovery and during the latter part of World War I, Cities Service had 100 strings of tools operating in the El Dorado field, with a top of 159 reported at one time. Transportation was by horse-drawn wagons and the Cities Service

FIRSTS IN EL DORADO

- First Wide Area Geological Survey
- First Junior Engineering Training Program
- First Electric Drilling and Pumping in Mid-Continent
- First Non-Water Softening Emulsion-Splitting Chemical (forerunner of modern detergents)
- First Large-Scale Operated Central Oil Dehydrator
- First Large-Scale (700 wells) Down-the-Hole Treatment for Corrosion
- First Repressuring Secondary Recovery Project in Kansas
- First Air-Oxidation Process for Manufacturing Petrochemicals
- First Vapor-Sealed Tank Decks with Pressure-Vacuum Relief Valves
- First Steel Tubular Derricks Developed in Mid-Continent

AN OLD BULL WHEEL sets the tempo for this picture that uses one of the old-time tank batteries as a backdrop. The wooden housings shown cover some of the first vapor-proof wooden tanks initiated here in the El Dorado field.

MODERN JACK-KNIFE DRILLING RIG is shown framed by pumping jack of a 632-ft producer, which was completed June 1917 and is still producing. Close by are wells producing from the Arbuckle, Douglas sandstone, Marmaton sandstone.

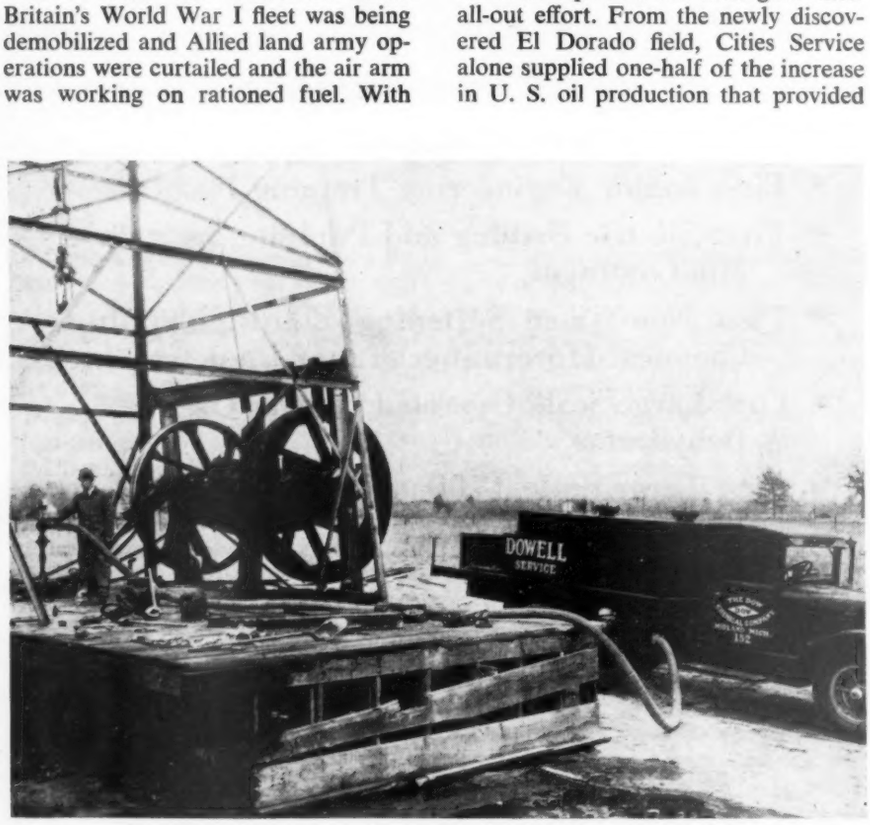
livery department had 100 buck-boards in operation and a corral of horses.

"Sea of Oil"

It was about this time that the Allied war machine was foundering through lack of fuel and lubricants. Great Britain's World War I fleet was being demobilized and Allied land army operations were curtailed and the air arm was working on rationed fuel. With defeat staring the Allied armies in the face, an appeal was sent to the United States for vital petroleum that could stem the tide and revitalize the armed forces.

To this appeal, Cities Service engineers and production men gave their all-out effort. From the newly discovered El Dorado field, Cities Service alone supplied one-half of the increase in U. S. oil production that provided the sea of oil on which the Allies floated to victory.

The sprawling El Dorado field, force-developed to meet the demands of World War I, soon had multiple problems. There were the drilling problems on the "deep" wells, there were completion buggaboos, the encroachment of salt water, and corrosion and emulsion problems. This was before the day of the petroleum engineer, the reservoir engineer, and the corrosion engineer.



TYPICAL TREATMENT during the early history of acidizing in the southwest. This truck was equipped with two 500-gal, rectangular steel tanks and a 2-in. Blackmer rotary pump, rated 200 gpm at 180 psi. Acid was pumped through the steel-armored hose.

Engineering Training

Cities Service had been pioneering in the practical field of training of technical graduates through its Junior Engineering Training Program. This program was stepped-up to meet the increasing demand for a concerted approach to the problems of the day. Eight technical graduates were employed in 1916 and 24 the following year. In 1919, more than a hundred technical graduates were enrolled in the Junior Engineering program, with approximately half of them assigned to El Dorado field problems. Others worked on El Dorado's problems back in the company headquarters at Bartlesville.

It was at El Dorado, then, that the know-how and practical knowledge of of the work-calloused oil veterans of Pennsylvania and the technical theory of the engineering graduate were fused together in a common approach to the problem of the fast-growing field.

And, while El Dorado's oil went far in winning the first World War, its real claim for space in oil industry

annals is based more on the pioneering strides in production research and engineering techniques.

Meet Operational Problems

With a history grounded in the electric utility field, electrification of drilling, pumping and other operations resulted, when available gas supply dwindled in 1918 and 1919 and supply of gas engines dropped below demand. In this switchover, Cities Service recorded another first in oil industry history.

It was only natural too, that when a central dehydrator for the entire El Dorado field was planned, that it should be electrically-operated. This, too, represented the first large-scale central dehydrator in the Mid-Continent area.

Emulsion problems that plagued the El Dorado engineers finally led to the pioneering development of emulsion-breaking compounds which made it possible to separate oil and water on individual leases to the satisfaction of royalty owners. This was the forerunner of modern emulsion breakers.

Highly corrosive water produced with the oil provided another task for Cities Service engineers. At El Dorado, in those early days, Cities Service was the first to utilize caustic soda on a wide-scale, down-the-hole treatment to prevent corrosion.

In their studies of oil well and pipeline corrosion, Cities Service chemists at El Dorado studied air and gas oxidation. Out of this research came the infant air-oxidation process for the manufacture of petrochemicals from natural gas. At El Dorado was established the first pilot plant for the manufacture of petrochemicals by air oxidation.

El Dorado field history includes the first known attempts to decrease vaporization losses from tank batteries. Tank decks were vapor-sealed. Pressure-vacuum relief valves for tanks were made in the Cities Service machine shop and it is recorded that oil gravity was appreciably increased.

Initial battery installations consisted of steel tanks but corrosion made it necessary to replace them with wood tanks within one to three years. These tanks were equipped with downspouts which also decreased losses.

A. J. Leonard, superintendent of the company's service department developed a sectional wooden derrick utilizing turnbuckles. Mr. Leonard designed the first steel pipe derrick known as the Leonard derrick. This derrick was built in the company machine shop and used throughout the later development of the field.

One of the forerunners of the modern pumping unit was patented by a company superintendent in the El Dorado field. By 1920 most of the wells

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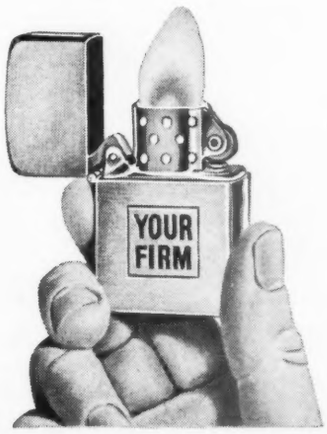

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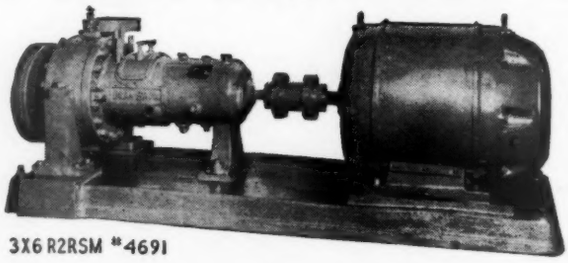
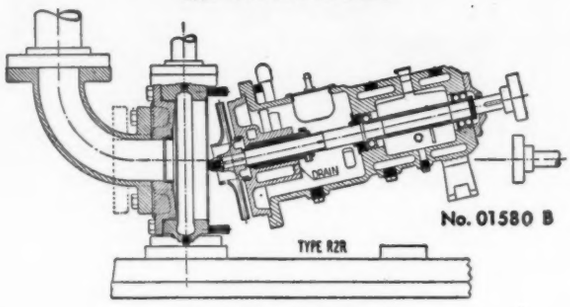
Type R2R Centrifugal Process Pumps



3X6 R2RSM #4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
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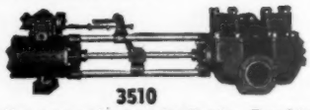
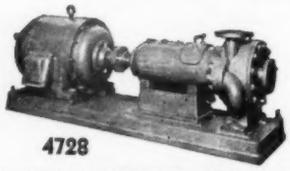


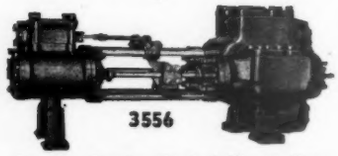
3510
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

4043 AA
Pedestal Mounted Centrifugal Pump

3833
Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



4728
Double Pedestal Bearing Centrifugal Pump



3556
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STAPLETON NO. 1 DISCOVERY. After discovering oil in the shallow formations, it was drilled down to the deeper pays. There were many shallow sand confirmations completed before Stapleton was completed in the deeper pays.

were equipped with the Ballard single reduction open gear.

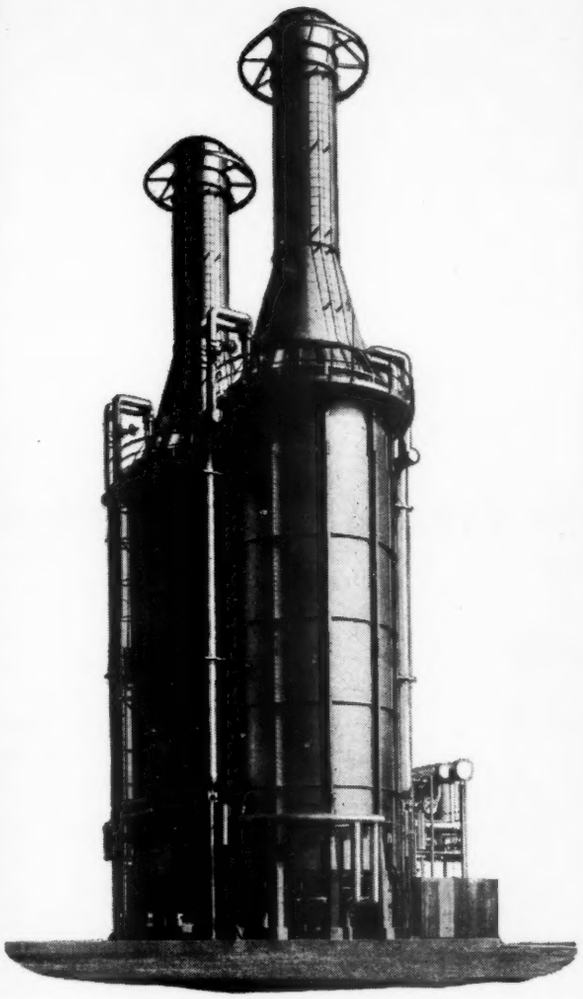
The El Dorado field was only a few months old when the advent of water brought predictions of early exhaustion of the field. Many of these prognostigators predicted the field would be plugged out within five years. As new problems arose to add fuel to the gloomy predictions of exhaustion, engineering development provided the solution and added still more productive years of life to the field.

Today, as the El Dorado field approaches its 40th anniversary and with a cumulative production of 215,322,000 barrels of oil to its credit, there's still life in this field that has refused to die. And, with the advent of water flooding, reservoir and production engineers predict an extension of another 15 years from this alone.

Discovery Well Produces

The Stapleton discovery well, after producing 150,000 barrels of oil, was abandoned in 1940 and an appreciative Kansas oil industry dedicated a monument to its memory. But, at the turn of this year, the old patriarch of Kansas oildom began producing again — the result of a waterflooding project in the shallow sand. They've put a new pumping unit over the Stapleton No. 1 and it's putting 18 to 20 barrels of oil in the tanks every day now — a pretty good comeback for a well that had been counted out almost 15 years ago. *

12,000 BARRELS PER DAY
17,000 BARRELS PER DAY
20,000 BARRELS PER DAY
21,000 BARRELS PER DAY



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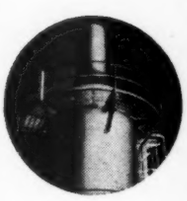

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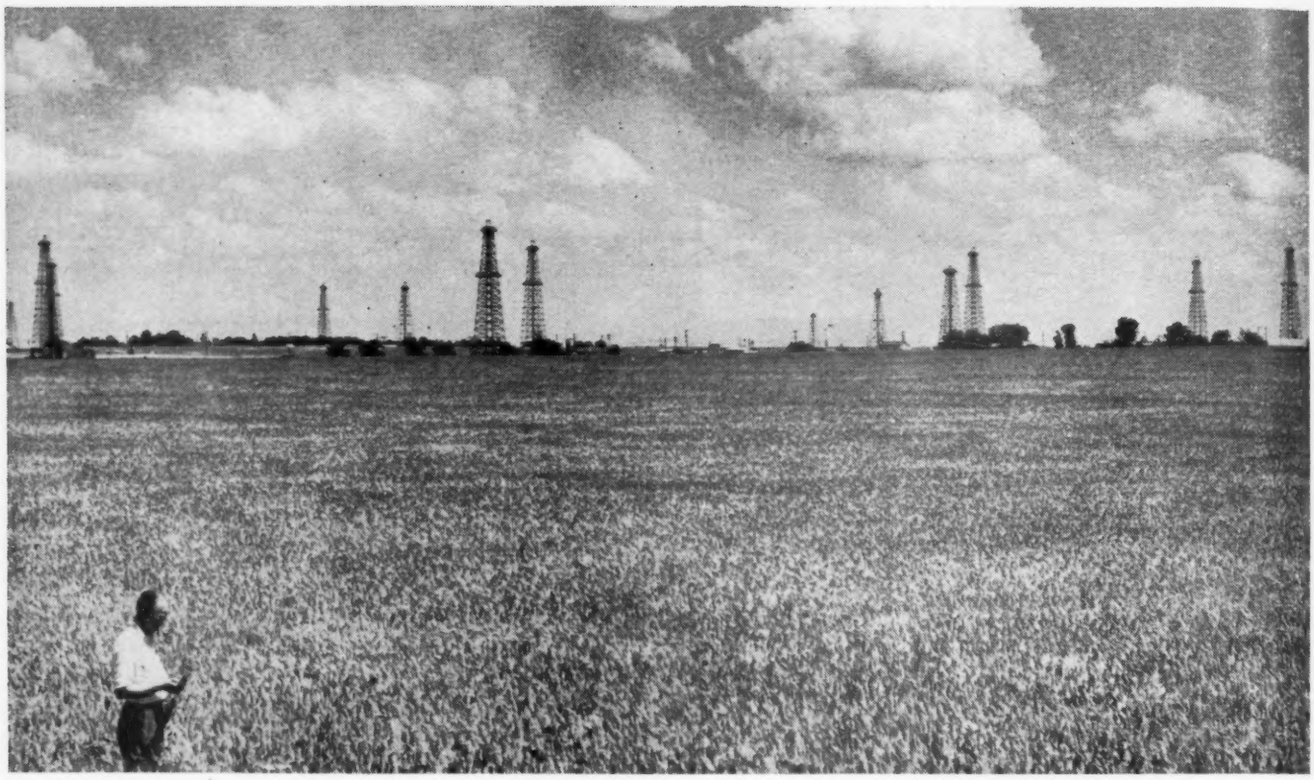


Kansas wheat fields are often planted with derricks.

Here is a state that offers a wide range of "deals" and nearly always finds some one to take them

A Look at Kansas Oil Through the Eyes of an Independent

GEORGE H. BRUCE

THOUGH historically rich in petroleum tradition and activity and currently the nation's fifth largest oil producing state, Kansas producers are good-naturedly kidded by their fellow operators in Texas as being "post hole" drillers.

In a sense, that is a true statement, and, paradoxically, in it lies the key to independent operators' success in the Kansas oil industry.

Although most major companies sustain activity in Kansas, few of them enter into extensive exploratory and development campaigns in this state, as there are vastly greater stakes to be played for elsewhere. They are unattracted, as the independent is, by an average drilling depth of 3500 ft and frequent, though comparatively small discoveries. Holding extensive acreage, they are, eager and willing to support ventures that offer moderate chances for success.

Cooperation Traditional

Kansas, therefore, is a land of relatively easily assembled deals and strikes of considerable magnitude are made in an atmosphere of cooperation and mutual help that has become a tradition in the area.

Though the tremendous post-war surge in activity and resultant multiplication of wells has spread production thinly, it is not difficult to make a Kansas well show a profit. They may be drilled and completed for an average of $35,000 to $40,000.

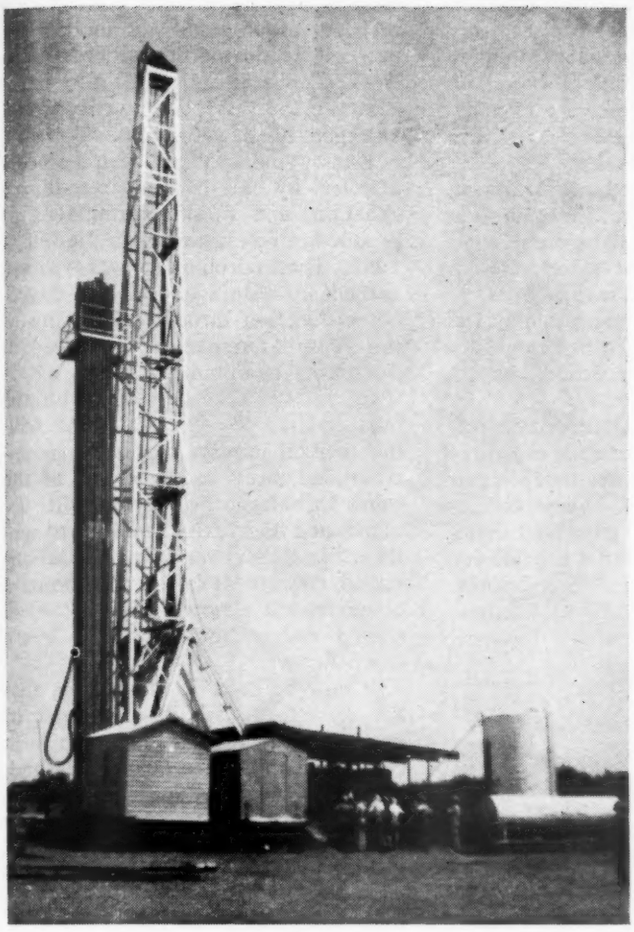
Above and below this median lie wide choices.

In southeastern Kansas, one may drill with reasonable chance of success, thanks to hydraulic fracturing, and find oil and gas at depths ranging from 900 to 2000 ft. Cutting corners, producers may complete these wells for an average of $15,000; for that money they get a small (usually Pennsylvanian) well with a moderately steep depletion curve.

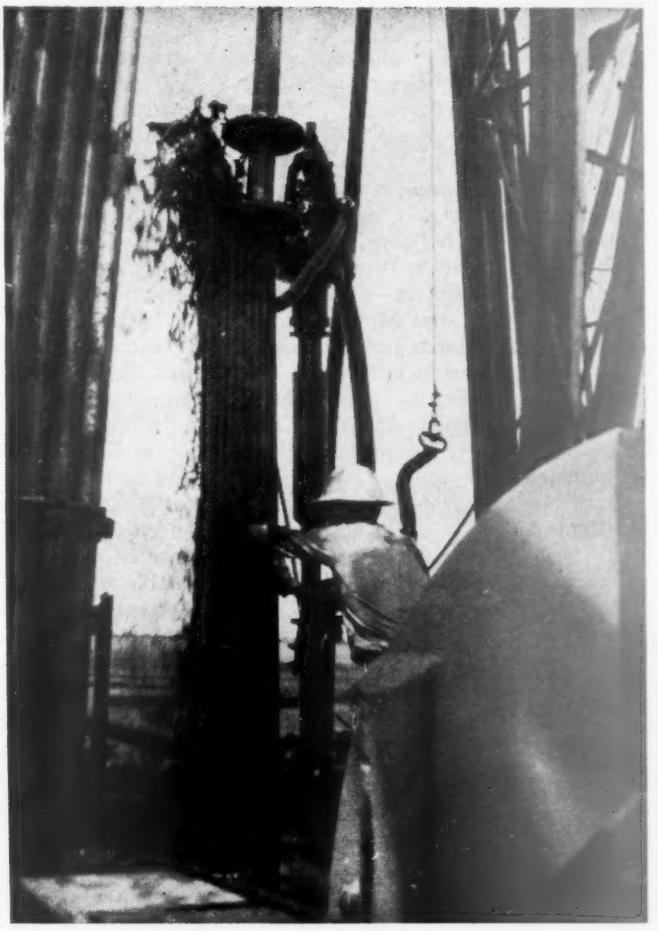
Nonetheless, the attractiveness of a series of wells in an unprorated area offering pay-off in a year or less and substantial profit in 18 months cannot be denied. The state geological survey estimates that nearly 3000 such wells were drilled in southeastern Kansas in 1953.

In central and western Kansas—the 3500 to 4500-ft area — possibilities for the independent are no less attractive per dollar invested, though here the reserves are proportionately greater

EXCLUSIVE



A drilling mast on Kansas plains.



Making a trip to change bits.

and the pay-off less rapid. In this area (and southwestern Kansas), producers drilled 4450 wells in 1953; of those, 2263 produced either oil or gas, a fact that is not encouraging unless it is recalled that considerably better than 1000 of the dry holes were wildcat tests.

Discoveries Numerous

Exploration yielded 156 new oil fields, 52 new horizons in established areas, and 27 new gas fields. Added to the state's production list were two new counties, bringing petroleum to 80 out of the state's 105.

Some of the strikes promise to be, or have become, lucrative discoveries. High upon the flanks of the Central Kansas Uplift, the Norton field in Norton County, tapping Arbuckle as it pinches off against the uplift, boasted 50 wells with potentials averaging from 150 to 300 bbl daily less than a year after its discovery.

This thoroughly documented edition of The Petroleum Engineer contains accounts of other encouraging and recent examples of what can be done in Kansas that will not be repeated here.

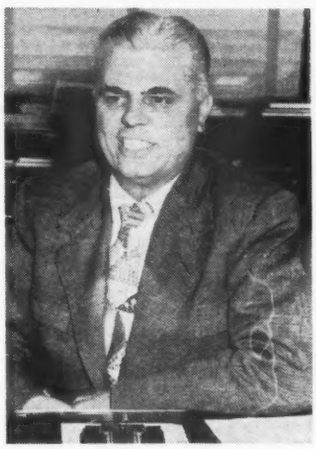
For the more venturesome explorer, Kansas offers growing possibilities in southwestern Kansas, geologically described as the Hugoton embayment of the Anadarko Basin, and in the geologically difficult and inadequately explored areas where the basin depositions lap against the uplift.

The latter, marginal areas, containing a wealth of unexplored, secondary structures and offering exceptional though more difficult opportunities for the discovery of accumulations in stratigraphic traps, is currently coming into its own as attested by lower Pennsylvanian, Lansing-Kansas City, and Arbuckle discoveries in Trego, Rush, and Pawnee counties.

Deep Area Next Frontier

Farther to the southwest, lies the deep basin area, offering all the probabilities inherent in thick marine depositions which have been subjected to more broad folding than is generally realized, and which progressively pinch off according to age as they thin out, up-dip, toward the north. In this area, which has tremendous future possibilities for those with the courage to enter, deeper exploration wells have been drilled for $100,000 and up. The stakes, however, are high. In the Hugoton gas field area, the risk can be hedged to a certain extent by the liklihood that wells may be productive in the Permian section,

The Author



George H. Bruce is president and owner of the Aladdin Petroleum Corporation, Wichita, Kansas. He attended Colorado College and Leland Stanford University graduating in 1923. Upon graduation he was employed by the Cities Service Oil Company in Kansas as a petroleum engineer. He organized and owned the Kansas Well Log Bureau. In 1929, he with associates organized the Aladdin Petroleum Corporation. His present professional affiliations include: President of the Kansas Independent Oil and Gas Association, director of Halliburton Oil Well Cementing Company, and director of the IPAA.

which produces at an average of 2600 ft.

From the success encountered in this area to date, it may be predicted with certainty that it will be the next big frontier for the Kansas independent producers.

Thus far, gas, distillate, and oil production in the area has been predominantly from the horizons at or near the unconformity at the Pennsylvanian-Mississippian contact — Marmaton, Cherokee, Atoka, and Morrow in the former, and Chesteran and Mermecian rocks in the latter — but recent discoveries in upper Pennsylvanian (Shawnee) and deeper Ordovician and Cambrian may well result in electrifying developments.

Back on the peripheral areas where the Central Kansas Uplift noses down southward into the flanks of the embayment, have been strikes of possible far-reaching consequences. In that south central Kansas area, Kingman, Harper, Barber, and Comanche counties have had recent pre-Mississippian successes indicating that much exploratory work remains. The latter county is immediately north of Champlin's recent Ordo-Cambrian discovery in Woods County, Oklahoma, that has disclosed structural potentialities unsuspected in rocks of these ages.

In all, prospects are such as to challenge the independent's imagination.

Kansas is fortunate in having excellent roads giving easy access to any section of land in the state. Mapping and geophysical operations based on accuracy of section lines are effected confidently without extensive surveys required in some oil states.

Oil industry taxes, though carrying more than their share of the state-wide burden, are generally favorable and are largely collected at the ad valorem level. The fact that oil tax revenues account for as much as 50 per cent of the revenues of some counties, logically and effectively cancels periodic efforts to impose a serverance tax.

Independent oil producers of Kansas are noted for their state trade organization known as the Kansas Independent Oil & Gas Association. This group, referred to as KIOGA, pioneered many state oil and gas laws that provide for ratable taking between wells and pools. Current conservation laws, administered by the Kansas Corporation Commission and its efficient conservation division, are regarded as models for new oil producing states. They have worked pre-eminently well over a period of many years, and no effort to revise them has as yet become necessary.

Kansas' industry has been seriously affected by the current over-supply situation, and drastic curtailment of production was instituted in the fall of 1953. That curtailment was relaxed as the Kansas storage picture improved, but production through the spring of this year has remained very close to the statuatory minimums.

In this respect, we share with the independents of other states the feeling that oil imports represent an uncontrolled threat to the ability of the states to balance production with demand, and there exists widespread sentiment in Kansas for quota limitations on oil imports. It is felt that positive congressional action on this problem should engage the efforts of every independent.

It may be seen, in conclusion, that the advantages and disadvantages of operations in Kansas have much in common with those of other states, and, subject to the limitations of the area, we prosper as others do elsewhere, in relation to our effort, a little vision and a little luck. In that we find a great American heritage, the privilege of being independent oil men. * * *

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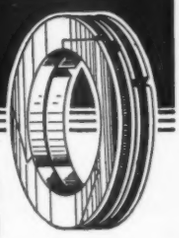

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Physical Properties of Kansas Crude Oils*

Data made available for use of operators in Eastern Kansas and of processors of crudes from this area

C. F. WEINAUG and J. P. EVERETT

FOR more than three quarters of a century oil has been produced from the relatively shallow sands of east-central Kansas. After production of oil by primary methods these fields have been abandoned in many cases. In some instances, however, productivity has been increased by repressuring with gas or air. In addition, water flooding has been applied to restore production long after a pool was abandoned for primary production. This method has also been used more recently to maintain the continuity of primary and secondary output. During recent years the trend has been steadily toward increasing quantity of oil produced by water flooding. The importance of water-flooding operations is evidenced by the fact that now more than 7,000,000 bbl of oil is produced annually in Kansas by this method. Most of the water flooding is being done in the eastern part of the state.

The rate of development for secondary recovery operations in the past has been influenced by numerous factors including the domestic and foreign situation as well as those within the oil industry itself. These factors could curtail completely the development of water flooding for a time, resulting in abandonment of production after the primary period.

With this possibility in mind, the State Geological Survey undertook to gather information concerning present active production which could be used to encourage further secondary recovery development. This information could also reveal whether or not some

*Publication authorized by State Geological Survey of Kansas.

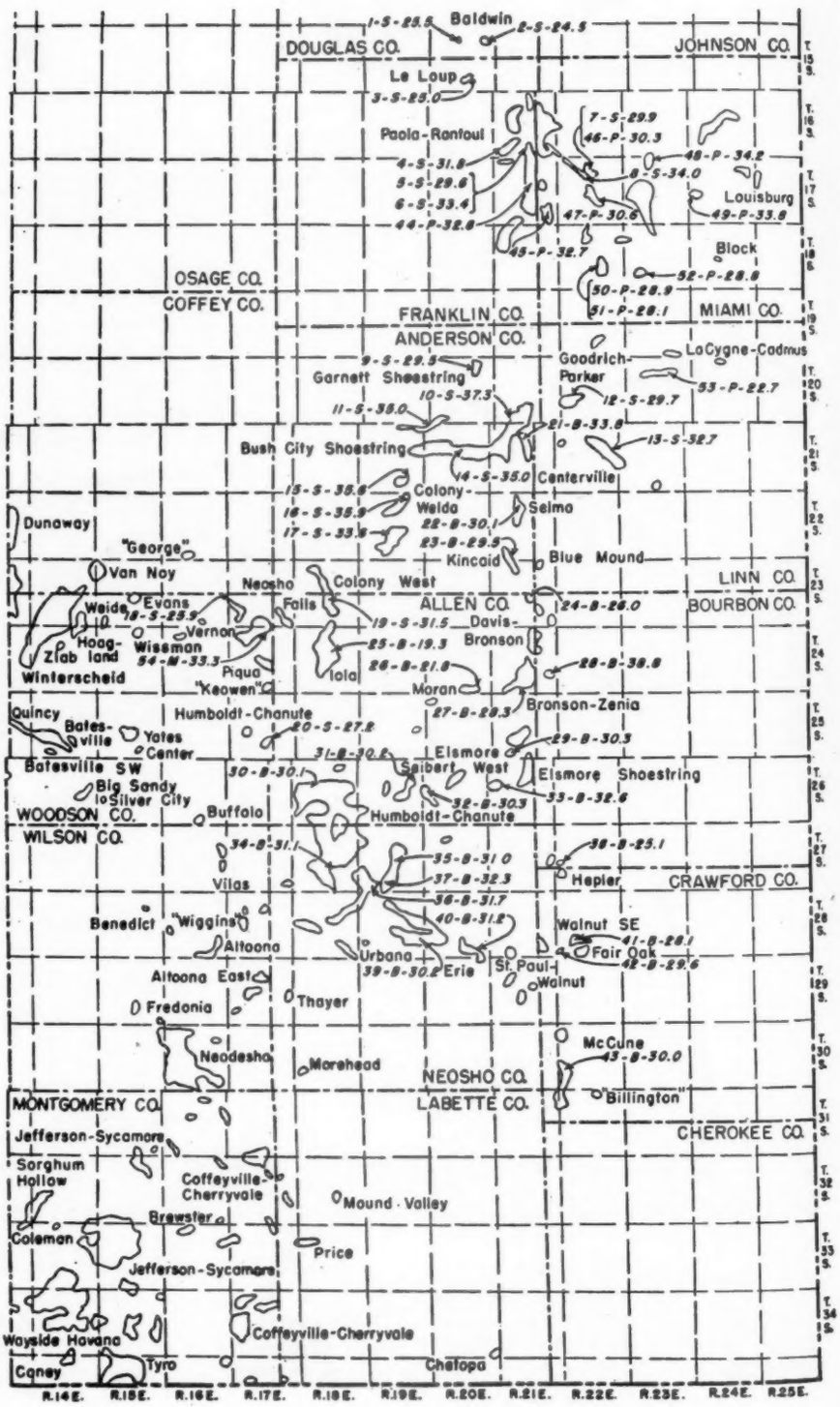

FIG. 1. Map of southeastern and east-central Kansas showing oil pools. The letter indicates producing formation (B, Bartlesville sand;" M, Mississippian limestone; P, "Peru sand;" S, "Squirrel sand"); the last number is API gravity at 60 F. Map from Weinaug (1951) Kansas Geological Survey, Bulletin 90, Part 4.

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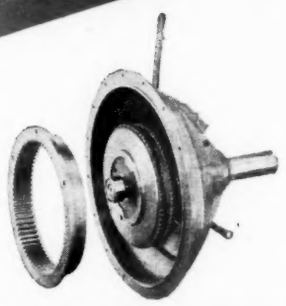

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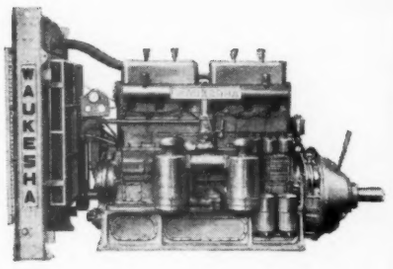

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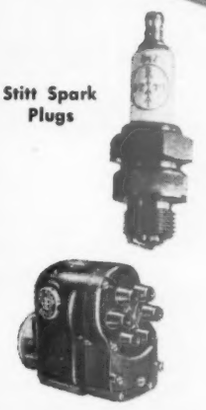

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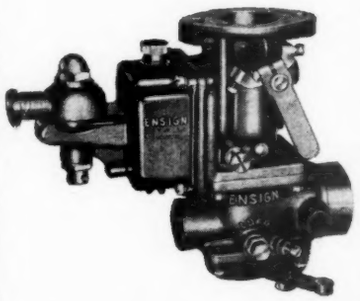

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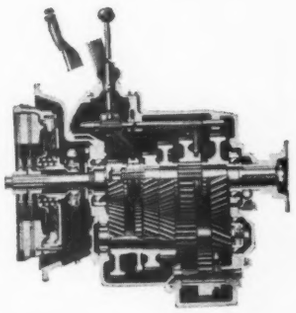

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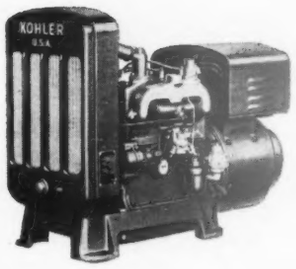

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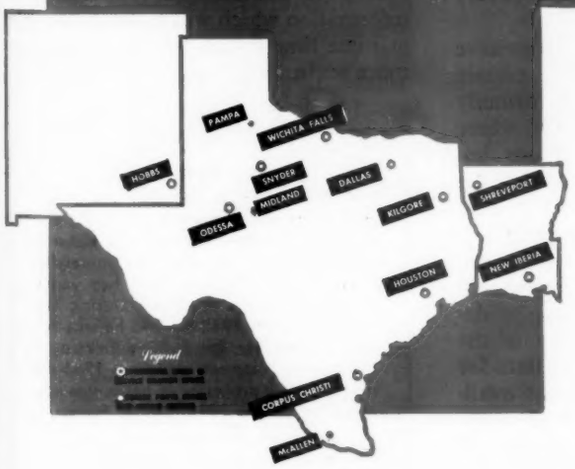

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Physical properties of samples of eastern Kansas crude oils.

No.	Producing formation	Location	A.P.I. gravity @ 60 F	Interfacial tension @ 60 F	Viscosity 70 F	Viscosity 100 F	Viscosity 120 F
1	"Miss. lime"	SE¼ 27-22-13E	39.2	29.14	4.976	3.349	2.612
2	"Bartlesville"	33-21-12E	38.0	25.80	4.647	3.160	2.446
3	"Burgess"	SE¼ 15-22-13E	37.7	23.29	5.243	3.412	2.640
4	"Bartlesville"	SE¼ 13-23-10E	40.4	30.31	4.541	3.050	2.463
5	"Miss. lime"	36-25-10E	34.3	29.13	7.008	4.468	3.517
6	"Bartlesville"	NE¼ 6-24-12E	41.4	34.40	3.729	2.641	2.125
7	do	SE¼ 3-22-10E	41.3	30.55	3.580	2.515	2.061
8	do	NE¼ 11-25-8E	39.6	34.80	4.284	2.953	2.409
9	do	SE¼ 12-24-9E	39.2	32.67	4.852	3.326	2.663
10	Topeka	NE¼ 8-28-11E	30.8	32.94	56.810	24.520	16.090
11	Kansas City	NE¼ 17-28-11E	35.7	30.93	7.423	4.677	3.690
12	Viola	SE¼ 24-21-10E	23.9	28.69	131.000	58.000	33.000
13	Miss. "chat"	SW¼ 34-21-10E	34.3	24.16	9.853	6.102	4.579
14	"Bartlesville"	SW¼ 7-35-3E	39.5	27.02	3.883	2.677	2.190
15	"Hunton"	NE¼ 25-16-10E	28.3	33.28	81.000	44.000	34.000
16	Simpson	NW¼ 18-35-3E	41.6	29.73	3.030	2.158	1.767
17	"Layton"	SE¼ 8-34-3E	37.3	25.38	6.220	4.047	3.216
18	Arbuckle	NW¼ 19-32-3E	36.5	33.93	5.990	3.909	3.105
19	"Stalnaker"	SE¼ 28-31-3E	38.4	32.61	4.868	3.247	2.582
20	"Hoover"	NE¼ 29-30-3E	36.3	35.96	6.288	4.080	3.183
21	"L. Peacock"	SE¼ 24-32-4E	40.2	32.09	4.494	2.978	2.411
22	"Peru"	NW¼ 32-31-6E	40.0	33.14	4.850	3.349	2.636
23	Arbuckle	SE¼ 21-31-4E	37.8	28.93	4.464	2.992	2.402
24	"Layton"	NE¼ 10-32-7E	35.7	34.10	7.574	4.757	3.709
25	Lansing	NW¼ 20-29-4E	39.1	30.14	4.738	3.082	2.499
26	Simpson	SW¼ 11-28-4E	32.7	31.61	8.545	5.253	3.252
27	do	NW¼ 23-28-3E	32.6	34.01	10.663	6.372	4.801
28	Viola	SE¼ 5-26-4E	39.2	31.86	3.764	2.627	2.134
29	"Hunton"	SE¼ 17-23-4E	33.9	31.92	7.408	4.687	3.613
30	Miss. "chat"	NW¼ 6-24-5E	42.0	31.48	2.921	2.104	1.749
31	"Potwin chat"	SE¼ 31-24-4E	44.0	31.76	2.464	1.804	1.510
32	Admire	SW¼ 5-25-5E	34.9	28.58	6.825	4.345	3.404
33	"Bartlesville"	NE¼ 24-29-5E	39.6	32.39	4.731	3.129	2.496
34	do	NE¼ 26-28-5E	41.7	28.49	4.941	3.290	2.595
35	Viola	NE¼ 9-27-6E	34.3	31.40	6.804	4.355	3.388
36	Miss. dolomite	SE¼ 34-28-6E	40.0	31.90	4.367	2.972	2.396
37	Cattleman	NE¼ 9-26-8E	39.6	32.39	4.904	3.282	2.665
38	Arbuckle	SW¼ 10-27-4E	40.1	31.21	4.176	2.842	2.308
39	Kansas City	SW¼ 27-26-7E	33.5	34.94	10.227	6.117	4.635
40	"Bartlesville"	NW¼ 11-28-5E	38.6	31.25	4.982	3.309	2.659
41	Arbuckle	20-26-5E	33.8	34.77	7.830	4.951	3.763
42	Lansing	12-26-4E	35.8	33.54	6.722	4.319	3.321
43	Simpson	9-26-5E	37.1	32.56	5.096	3.508	2.756
44	Admire	33-25-5E	37.6	29.88	5.318	3.546	2.782
45	do	20-25-5E	37.2	33.94	5.609	3.707	2.945
46	Douglas	21-25-5E	37.1	25.94	5.538	3.643	2.886
47	Marmaton	27-25-5E	37.8	31.57	4.842	3.223	2.575
48	Kansas City	NW¼ 13-27-7E	37.4	30.92	5.103	3.385	2.693
49	"Peru"	NW¼ 36-27-8E	35.7	32.28	6.368	4.109	3.213
50	Arbuckle	SE¼ 25-27-4E	32.7	27.69	8.264	5.090	3.908
51	Miss. "chat"	NE¼ 34-16-4E	35.7	34.85	11.269	7.134	5.495
52	do	SW¼ 28-18-4E	41.7	31.17	4.432	3.078	2.534
53	Viola	NW¼ 34-18-2E	31.5	37.35	34.918	18.506	12.765
54	do	SW¼ 27-19-1E	18.7	46.58	235.000	82.000	50.000
55	Misener	NE¼ 31-20-5E	37.5	29.78	4.990	3.366	2.697
56	"Hunton"	NW¼ 26- 2-14E	22.8	38.24	648.000	260.000	142.000
57	McLouth	3-10-20E	23.4	37.37	124.000	72.000	42.000

completely abandoned production can be flooded successfully. Also, in case some present production has to be abandoned, this information will be available when the situation becomes more favorable for secondary recovery development.

Secondary recovery operations have brought a new importance to certain types of technical data that formerly were not obtained at all, or else where considered to be of only minor importance to the problems of production. These facts, now needed in eastern Kansas oil production, include data on the physical properties of crude oil. Once a pool is abandoned it is often extremely difficult and expensive to determine the physical properties of the crude formerly produced; also data for many areas still active are not available. In order to obtain an adequate background of factual data on these old pools, which constitute future potential secondary recovery operations, the State Geological Survey has started the gathering of data on existing pools. This report gives the results of the first part of this study.

It is planned that future sampling and laboratory work will expand the scope of this information in conjunction with studies of subsurface stratigraphy and investigations of the character and petrography of the reservoir rocks. The ultimate goal is to assemble information which will make it possible at some time in the future to estimate more accurately in advance of flooding

The Authors

C. F. Weinaug is professor and chairman of the department of petroleum engineering at the University of Kansas. He obtained his degrees from University of Michigan, after spending two years at Aurora College in Illinois. During the war years from 1942 to 1946 he was research engineer for Phillips Petroleum research department, and from 1946-48 was associate professor of petroleum engineering at the University of Texas.

J. P. Everett is a member of the staff of the department of petroleum engineering, University of Kansas. A graduate of the University of Oklahoma, Everett taught at Oklahoma A. & M. College from 1949 to 1951. In 1951 he joined the University of Kansas. Everett spent almost four years with the U. S. Coast Guard.

the response of various crudes to this production technique or to any other technique which might be developed.

General information on oil and gas developments in eastern Kansas has recently been published by the Survey (Jewett, 1949), and an annual review of petroleum developments is also published by the Geological Survey. The most recent of these (Ver Wiebe and others, 1953) summarizes developments during 1952. The annual development reports published by the Geological Survey now contains a special summary of secondary recovery operations, particularly in eastern Kansas.

Sampling Procedure

A gallon sample of each oil whose properties are reported in this paper was obtained at the lease and sealed immediately. The samples were then brought to Department of Petroleum Engineering laboratory at the University of Kansas where their physical properties were measured promptly.

The samples were gathered during the months of June, July, and August of 1950 from the east-central Kansas area. The locations of the wells from which samples were taken are shown in Fig. 1 and are listed in Table 1. An attempt was made to obtain a fresh sample in each case. This was not possible in every instance, however; therefore, some of the samples were taken from stock tanks. It is realized this could not give completely comparable results due to weathering, but the data obtained are sufficiently close to retain the correct relative position among the samples. Most of the oils have little or no gas solution when they are produced.

Physical Properties

The API gravity has been used to correlate other physical properties, as well as to indicate origin and similiarity of crude oils; thus this property was measured for each crude oil sample. Also because the price of oil is based on the gravity, this property is generally available even for abandoned fields. Thus it could be used as a basis for estimating other physical properties when samples are not available.

Viscosity is a direct measurement of an oil's relative resistance to flow. In a given sand body, the higher the viscosity of the oil the greater the pressure drop required in order for the oil to move through the sand. Also, since the viscosities of the water in the various formations and that of injected waters are nearly identical there is a pronounced tendency for the injected water to by-pass the more highly viscous oil.

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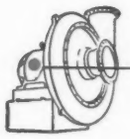

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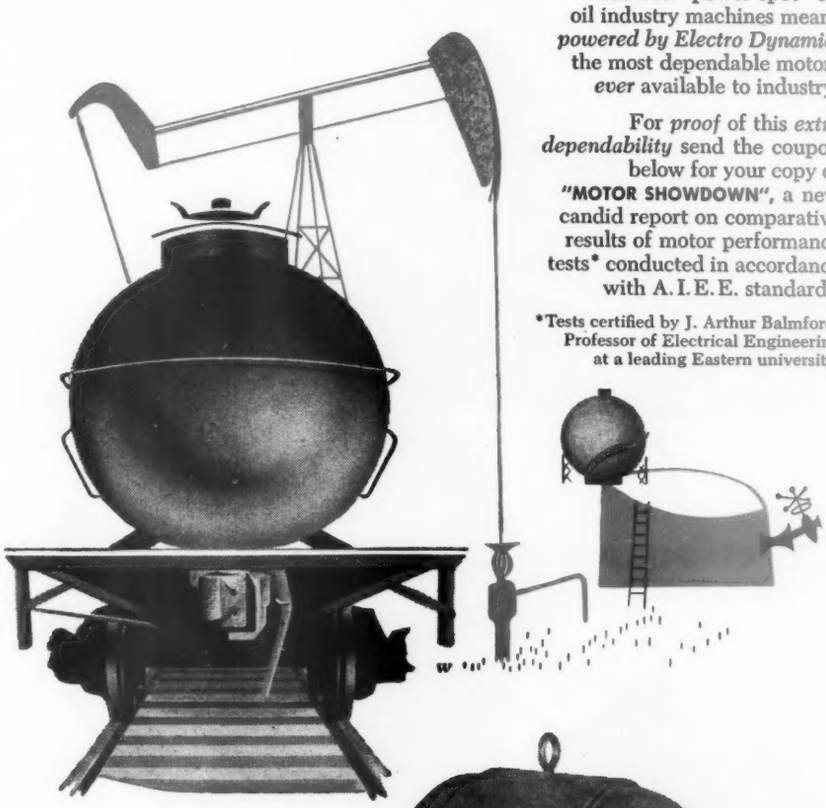

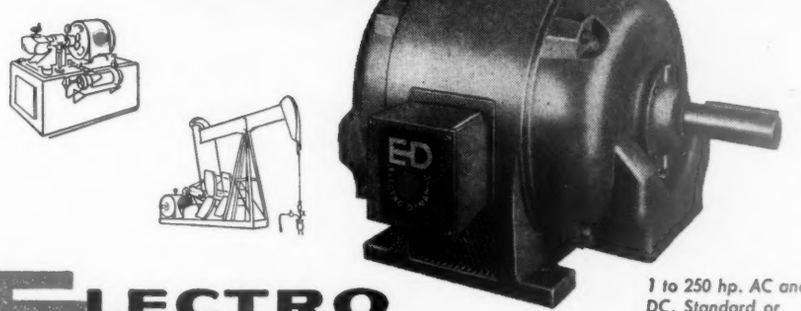

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tact. This interface contracts to occupy the smallest possible area. If the interface is formed in a capillary, the liquid which wets the capillary tends to spread a thin film over the capillary wall, increasing the interface surface area between the two liquids. However, the tendency for the interface to contract is still present so that the liquid which wets the capillary enters the tube, decreasing the interfacial area; this action produces a force that will displace the other fluid. As the capillary becomes finer this force increases; in a system of fine capillaries such as occur in many reservoir rocks, it becomes an important factor in displacing oil with water, which generally wets the rock. The tendency for the interface to contract is called the interfacial tension. The determination of this physical property is included in this study as a measure of the oil-water interface's role in flooding operations.

Gravity. — The A.P.I. gravity for each oil was determined by means of hydrometers according to the American Petroleum Institute standard No. 526-39 (Am. Soc. for Testing Materials, 1949). The determinations were made at room temperatures and the national standard petroleum oil tables (U.S. Dept. Commerce, 1936) were used to reduce the observed values to 60 F. These tables were also used as a basis for determining the gravity at other desired temperatures similar to the temperatures at which the viscosities and interfacial tensions were determined.

Viscosity. — The viscosity of each oil was determined at 32 F and 100 F using a modified Ostwald viscosimeter. The procedure used was the tentative method of test for kinematic viscosity (Am. Soc. for Testing Materials, 1949, Designation D445-46T, method B). The method is essentially a determination of the time required for approximately 3 cc of oil to flow through a capillary tube about 3 in. in length.

The viscosity was determined at only two different temperatures, as the American Petroleum Institute standard No. 533-43 (Am. Soc. for Testing Materials, 1949) provides a convenient means of finding the viscosity at any temperatures between the ones at which this property was measured. It should be noted that the viscosity also can be ascertained at temperatures slightly above and below these determined values.

Interfacial tension. — The interfacial tensions were measured by means of the double cylinder apparatus described by Bartell (1938, p. 69). The method consists principally of placing the oil and water in a vessel, then determining the height to which water rises above the oil-water level in a capillary tube located vertically between the liquids. The measurements were made at 80 F since this temperature could be maintained conveniently.

Data table. — The test data for 57 samples of crude oil from east-central Kansas are given in Table 1. General conclusions concerning the physical properties of eastern Kansas crude oils and the effect of these properties on flooding operations cannot be made until a more complete inventory has been done. The present report serves primarily to place these data now available in usable form for owners, operators, and companies in eastern Kansas.

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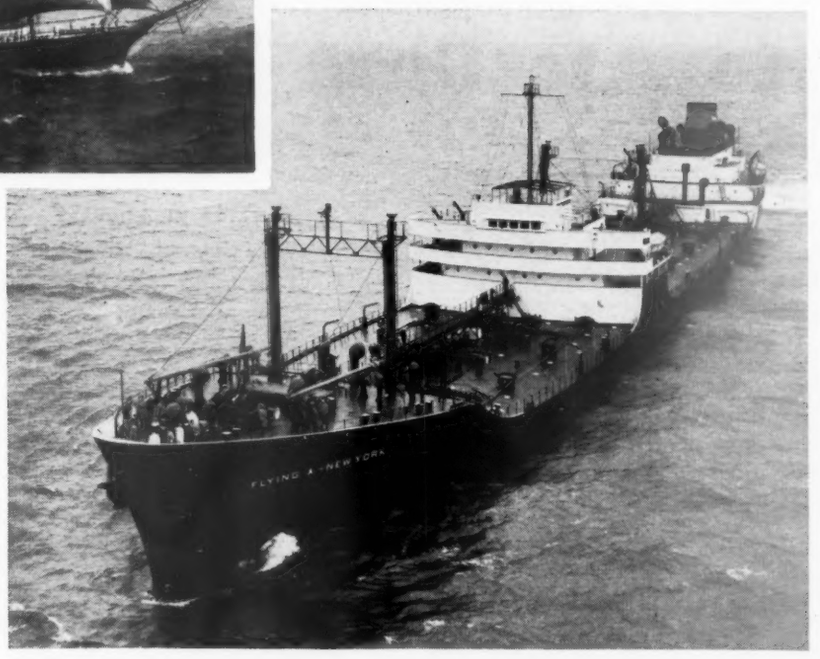

Tide Water S. S. Flying-A-New York off the Virginia coast on recent sea trials.

Time spanned by Tide Water Associated is appropriately pictured by the masted tanker that carried oil across seas in the company's infancy and the giant modern tanker recently launched on the Atlantic Coast.

Tide Water Enters 75th Year With Bright Prospects

TIDE WATER Pipe Company, forerunner of today's Tidewater Associated Oil Company, was created in the turbulent days following the Civil War. One of the few surviving companies of that era, Tide Water can take credit for originating and beginning many modern methods of transporting crude oil.

This year marks Tide Water's 75th year of existence. It had its birth on November 22, 1878 in Titusville, Pennsylvania, when Byron Benson, lumberman, Robert Hopkins, Civil War major, and partner of Benson, and David McKelvy, Titusville lawyer, met and organized The Tide-Water Pipe Company, Ltd.

Undismayed when oil dropped from $2.42 to $1.19, and was on its way to 82 cents, the group prepared to build a pipe line that would carry oil over mountains, an unprecedented plan for those days. In 1879 the first oil was forced through pipes. Seven days later it reached its destination and flowed into storage tanks, 104 miles away on the other side of the Allegheny Mountain range.

From 1880 to 1887, Tide Water Pipe Company moved into the oil refining end of the industry, in order to find outlets for its crude oil. The company's first step was to build the Chester refinery near Philadelphia with a capacity of 2500 bbl a day. Later, through Ocean Oil Company, another refinery was built, and in Bayonne, New Jersey, through Polar Oil Company, a lubricating plant was built.

By now oil was flowing steadily from Pennsylvania to New Jersey but refining facilities were unable to handle the flow, so a further step in refining was taken. It was decided to concentrate all refining activities at the port of Bayonne, and to accomplish this Chester Oil equipment was shipped to Bayonne, where Ocean Oil and Polar Oil companies were consolidated along with an independent refinery. In 1888 these companies were organized under Tide Water Oil Company.

In the early 1890's leaders in the firm became interested in still another phase of the industry, and purchased a small operating organization in Pennsylvania. This company headed westward, and explored the Mid-west, bought land, and began drilling operations. In 1913, 23 years after its beginning, Tide Water Oil Company had 2000 producing wells.

In 1901 the Associated Oil Company came into existence in California to create new markets for petroleum. The firm induced the Southern Pacific Railroad to try oil as a substitute for coal for powering its engines. Beginning in 1904, the railroad bought 10,000,000 bbl over a three-year period, and by 1909 Southern Pacific owned 51 percent of the stock.

Associated completed an 8-in. line with a daily capacity of 25,000 bbl and with a pipe line system of 600 miles in 1908. Many accomplishments are attributed to Associated, among them completion of the first submarine oil line in the U. S.; building of the first solvent refining unit in America and development of Ventura Avenue field.

In 1926 a holding company was organized known as Tide Water Associated Oil Company and it acquired control of Tide Water Oil Company and Associated Oil Company. The three were merged in 1936.

Today the company's operations are divided into three units — Eastern, Mid-Continent, and Western division. From its small beginning 75 years ago, Tide Water now has a gross annual income of $473,437,093. * * *

XUM

Conveniences of modern life are contributions of technical men—to assure progress we must learn—

How to Cure Engineer Shortage

FLOYD A. LEWIS*

IN a recent address before a national engineering society, the president of one of our large steel companies said that "the shortage of engineers in this country must be overcome if our standard of living is to be maintained." With more than 40 per cent of our industries now dependent upon engineering manpower for their very existence, the engineer shortage looms as one of the most serious problems facing the nation today.

Why is there an engineering shortage and how can the problem be solved? Like the majority of problems, a careful examination of the causes will help in finding a solution. Briefly we have a shortage of engineers because not enough young men, and women, have been enrolled in our engineering colleges to meet the rapidly expanding needs of our increasing technological age. In other words, the supply of new engineers has been diminishing at the very time when our needs have been increasing. The problem can only be solved by convincing more young people that they can find satisfying careers in engineering work.

What Is an Engineer?

Unfortunately, not many people other than engineers really know what an engineer is or does. A recent government document defines a professional engineer as "a person who, by reason of his special knowledge of mathematics and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience is qualified to apply such special knowledge for the purpose of rendering professional services or accomplishing creative work, such as consultation, investigation, evaluation, planning, design, or supervision of construction for the purpose of assuring compliance with specifications and design in connection with structures, machines, processes, works or projects." Quite a mouthful!

Of course, this definition was not intended to tell the public what an engineer is, but it does give some idea of the complexity of engineering work. A recent statement by a prominent engineering executive is simpler: "It is the engineer's responsibility to take new research discoveries as they come along and to put them to work for the benefit of man, and to find ways of doing it that industry and the people can afford." To this should be added that many engineers are themselves engaged in research work.

Contributions to Present Day

Evidences of the engineer's contributions to modern life are all about us. Some are obvious like the electric light, telephones, radio and television, automobiles, aeroplanes, household appliances, and frozen foods, to name a few. Others, although equally important, the public has never head about such as: The many devices necesssary to provide electric service that seldom fails, drawn tungsten filaments that gave us high quality electric light and long-lasting lamps, tungsten alloys for high speed cutting steel that perhaps did more than any other single invention to increase production of metal goods, standardization which made mass-production methods possible. And the surface has scarcely been scratched.

Conveniences of modern life, most of which we take for granted, were made possible by engineers. As life becomes still more complex, more and more engineers will be required. But even to meet some of our basic needs in the future will demand more technical man power. Take the problem of feeding an expanding population, for example. According to a recent government report, an increase of 40 per cent in our agricultural production will be necessary by 1975 to feed the number of people we will have in the United States by that time. This increase can only be brought about by a wider application of technology to increase crop and livestock yields per acre of available farm land. This is a clear indication of the need for more engineers and other technical people in agricultural and related fields. What is true of agriculture also holds for other phases of our everyday life.

Defense too will require more technical manpower, and here the need may become even more acute as the complexity of our weapons continues to mount. After the outbreak of hostilities in Korea, the National Securities Resources Board, through its director, Robert L. Clark, asked Engineers Joint Council to prepare a program "for the most effective utilization of engineers in the national effort and make recommendations as to how such a program could be best administered." The Council is a joint organization of the leading national engineering societies and thus is representative of a large part of the engineering profession in the United States. To carry out the Government's request, EJC appointed a 20 member Engineering Manpower Commission.

One of this Commission's first moves was to conduct a survey of the nation's engineering manpower, its needs, and expected future supply. This survey showed an unfilled demand for more than 60,000 engineers in the United States, with still worse shortages to come.

Engineers Not Horn Blowers

Engineers themselves are partly to blame for this shortage, not because they have ever tried deliberately to exclude new recruits to their ranks so as to reap greater financial rewards, but quite the contrary. They have been so busy developing the conveniences of modern life and making them cheap enough for all to enjoy that they have had little time to tell us about their work. Others, of course, have been developing the atom bomb and other modern weapons that have enabled us to keep our nation free.

Engineers are traditionally a modest crowd and abhor any action that might smack of horn blowing. Furthermore, few of them are able to discuss their work in terms the public can understand. Most of them even have diffi-

*Dudley, Anderson, and Yutzy.

EXCLUSIVE

culty speaking to groups of their own kind at engineering society meetings. Unfortunately, many cannot effectively get their ideas across to the boss either unless he too is an engineer.

Thus engineers have done so little to inform the public about their work that the engineering profession hasn't appealed to enough promising young men to meet today's needs. Yet engineering work can be just as exciting, stimulating, and challenging as either law, medicine, or the other professions; often more so. Not enough young people know this because the engineers have not done enough talking or writing about their work in simple language.

Of course, the present shortage of engineers cannot be explained away quite as simply as that. There are other reasons, some of which go back to the dark days of the 30's. Many people blamed the engineers for the great depresssion. The machines that engineers developed to make things cheaper so that more pepole could buy them had put thousands out of work, so the story went. The facts are that engineers have created many times more jobs than they have destroyed, and better paying jobs too. But the people didn't know this, and many don't know it today either, because the engineers haven't told them about it.

Engineers, along with big business, thus became one of the scapegoats and people who would have known better if they had been informed clamored for a holiday on engineer training. This kept many promising young men from studying engineering who would otherwise be doing engineering work today.

The same situation contributed to a serious shortage of engineers during World War II. The shortage then was aggravated by the indiscriminate drafting of young engineers and engineering students into the armed forces. The increasingly technological nature of modern warfare naturally means that our armed forces must have more engineers too, but it doesn't mean that we should draft engineers who are essential to the national health, safety, and welfare at home and put them into non engineering military service. Yet that is exactly what happened during World War II and we had the doubtful distinction of being the only major power to waste its vital technical manpower in this manner, and are still doing it.

One of the earliest recommendations of the Engineering Manpower Commission was that this practice be stopped. Some steps in this direction have now been taken, but we still have a long way to go. Here's another instance where adequate information on the engineer's role would help.

The present shortage of engineers is worse because of the number required for defense production. With modern life becoming more and more technological, however, we would have a shortage even if we didn't have a big defense program. This is strikingly revealed in industrial statistics compiled by the Engineering Manpower Commission which show that on the average one engineer is required for evey 52 workers in industry today compared with almost twice as many workers 20 years ago. This trend is continuing and some plants even today need a much higher percentage of engineers. A plant recently placed in operation by one of the big chemical manufacturers, for example, requires more technical than nontechnical men to operate it.

Industry is trying to lessen effects of the shortage by making better use of the engineers it has and can get. Promising young men having technical aptitudes are being trained to do semi-technical work not requiring full engineering training. Engineers themselves are thus being relieved wherever possible of duties that can be performed by others under their supervision. In some cases, women with technical training and aptitudes are serving in these capacities. Industry and engineers will both benefit from these efforts, but there will still be a serious shortage of technical man power for many years unless there is a sudden large increase in engineering college enrollments.

Perhaps one of the strongest reasons why engineering has not attracted more young men in recent years is that salaries have been too low. Some waiters in New York night clubs, for example, are able to support their families in higher style than the majority of engineers. Some salesmen in high class department stores working entirely on commission are today receiving more compensation than many chief engineers. Such conditions do not stimulate young men graduating from high school to embark on the four years or more of hard work required to earn an engineering degree.

Salaries Cause Shortages

The inexorable law of supply and demand is slowly raising the level of engineering salaries, especially for men just out of college. Starting rates of from $300 to $400 a month are common. But many engineers with years of experience are still being paid inadequate salaries. One needs only to scan the want ads to find evidence of this. Even the ads appearing in a recent issue of a large engineering society journal offer $7000-$8000 for an electrical designer with at least 10 years' experience, $7800 for an electrical engineer to serve as a components laboratory chief, $5400-$6000 for a plant superintendent, $3800 for an assistant professor to serve on a nine-month schedule.

The chief highway engineer of one of our populous eastern states recently said that below-the-market wage scales are endangering acquisition of the stabilized technical organization needed to develop and expand the state's road network. Despite a general 10 per cent salary increase, he said, the state has not been able "to attract properly qualified engineering talent." Many other examples of inadequate salaries could be cited.

The low salary scale has also worked in other ways to deplete our engineering manpower. Many engineers finding the monetary rewards for engineering work unsatisfactory are attracted to more lucrative fields where engineering training is advantageous. Some enter fields where their training is not needed at all, and a great deal of competent engineering manpower is lost to the profession in this manner.

This adds up to the fact that the engineering profession does not enjoy the level of prestige which it has well earned. The term "prestige" is often not fully understood, although simple reference to a good dictionary will make its meaning eminently clear. Webster's Collegiate defines it thus: "1. Power to command admiration; hence eclat; renown. 2. Ascendancy derived from general admiration or esteem; commanding position in men's minds." Because the public does not thoroughly understand the engineer's essential role in modern life, the engineering profession does not hold a "commanding position in men's minds."

For some years engineering leaders have felt the need for greater prestige for their profession. They have recommended various courses of action. One of their first suggestions was that the engineer's training be broadened. Courses in social sciences and the humanities were thus added to many engineering college programs.

Unfortunately, four year engineering curricula are so heavily loaded with essential courses that there is little room for additional subjects. So in order to provide for social studies and the humanities, some colleges added an extra year to their schedules. Some have optional four, five, or six year courses. Undoubtedly such courses have broadened the engineers who have taken them, but it is doubtful whether they have raised the prestige of the profession very much.

One recommendation was that engineers take more active part in their local civic and other community activities so as to become better known. Many engineers, however, and especially the younger ones, find it difficult

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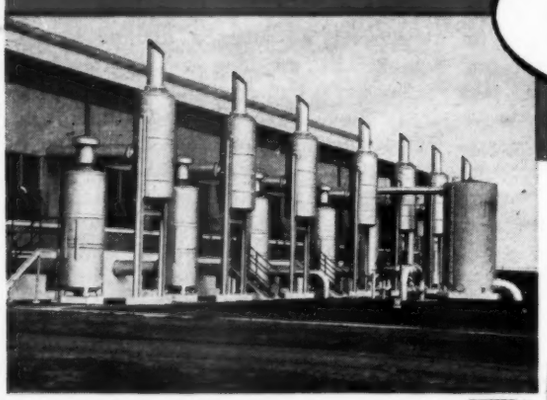
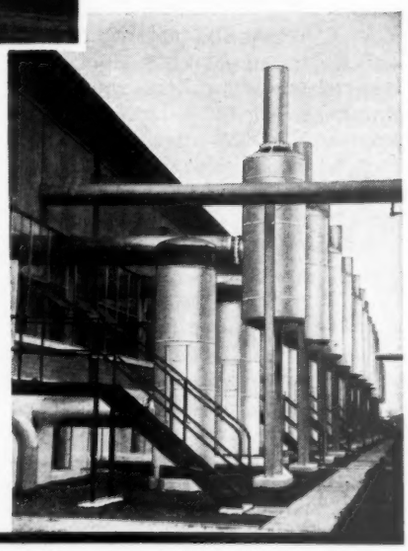


Below: Exhaust snubbers and combination air filter snubbers engineered and built for four 1,600 h.p. and eight 2,000 h.p. gas engines at Station #1, Agua Dulce, Texas.

Above: Seven exhaust snubbers and seven combination air filter snubbers designed to meet the silencing requirements of seven 2,000 h.p. gas engines at Station #9, Bloomington, Texas.



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to devote the necessary time to these things. The profession has advanced so rapidly that engineers must spend a lot of their spare time reading technical journals just to keep up to date on their own specialities. Community activities cost money too, and the engineers' low salaries have not left much spare cash for nonessential things.

Engineers as a group, nevertheless, are now more active in community affairs than they were, and this has helped them to become better known. Unfortunately, it has not raised the prestige of the profession very much because these activities are nonengineering in character, and professional prestige must be based on professional achievement.

Recognizing that the public must be told more about what engineering contributions mean in everyday life if the profession is to hold a "commanding position in men's minds" and thus gain prestige, a number of engineering groups have launched public information programs. Most of the engineering societies, for example, now supply news material on their activities to the newspapers and news magazines.

The American Chemical Society has an educational program to acquaint the American public of the role of the scientist and engineer and the impact of science and technology on modern living.

The profession during 1952, under the aegis of the 100 year old American Society of Civil Engineers, celebrated its "Centennial." Most of the country's national engineering societies held special commemorative meetings. These meetings provided a springboard for many newspaper and magazine articles on engineering achievements of the past century.

The Engineering Manpower Commission has a program to inform the public of the importance of the engineering function and to assure more effective use of engineers in industry, construction, and the armed forces.

Better Public Relations

The National Society of Professional Engineers is conducting one of the broadest gage public relations program of any of the engineering groups. It has spent more than $50,000 in preparing, publishing, and distributing its Executive Research Survey Reports. The first two discuss: "How to Improve Engineering-Management Communications;" and "How to Improve the Utilization of Engineering Manpower." Two more are scheduled, to deal with: "How to Attract Qualified Engineers," and "How to Train Engineers in Industry."

Industry is also attacking the problem. Vocational guidance conferences

are being held with schools in many centers, and boys with technical aptitudes are being urged to study engineering; girls too. General Motors has issued a pamphlet "Can I Be an Engineer?" and is circulating it widely in the high schools. Some companies are offering scholarships to promising students who otherwise could not afford to go to college.

There is some indication that these efforts are bearing fruit. For example, a survey conducted in 1952 by *Boy's Life*, official Boy Scout magazine, showed that engineering and scientific work led the list of preferred vocations by a large margin. Out of a total of 702 boys between the ages of 11 and 17, 28.9 per cent said they want to go in for this type of work. Whether they will still feel the same way when they are ready to enter college, of course, remains to be seen.

How far any of these efforts will go toward increasing our future supply of engineers depends primarily on two things: (1) whether the information given the public is brought down to a level that the average person can comprehend, and (2) how long they are continued.

If the true significance of the vital role of engineering in modern life can be forcefully brought home to the public, prestige of the profession will undoubtedly be raised and more young men and women will be attracted to engineering work. But educating the public on a complicated topic like the function of engineering in modern life is a difficult task. It is a job that takes time and one that never ends, for the public is constantly changing and expanding. Any celebrity knows that the public memory is amazingly short.

Too many industrial executives are still inclined to regard engineers more as a necessary evil than as one of their vital resources. Far too many think the present shortage is only temporary in nature — "for the duration of the defense program."

It is up to the engineers themselves to correct these impressions. They must see to it that their story is told to the public and on a continuing basis, if they would raise the prestige of their profession to the level that their good works have amply justified. Doing this would help to attract to the profession the increasing number of young engineers we must have. * * *

College Aid Fund

Standard Oil Foundation, Inc., non-profit Indiana corporation financed by Standard of Indiana, has voted to make available $150,000 for use this year in aiding privately financed four-year liberal arts colleges in 14 Midwest states.

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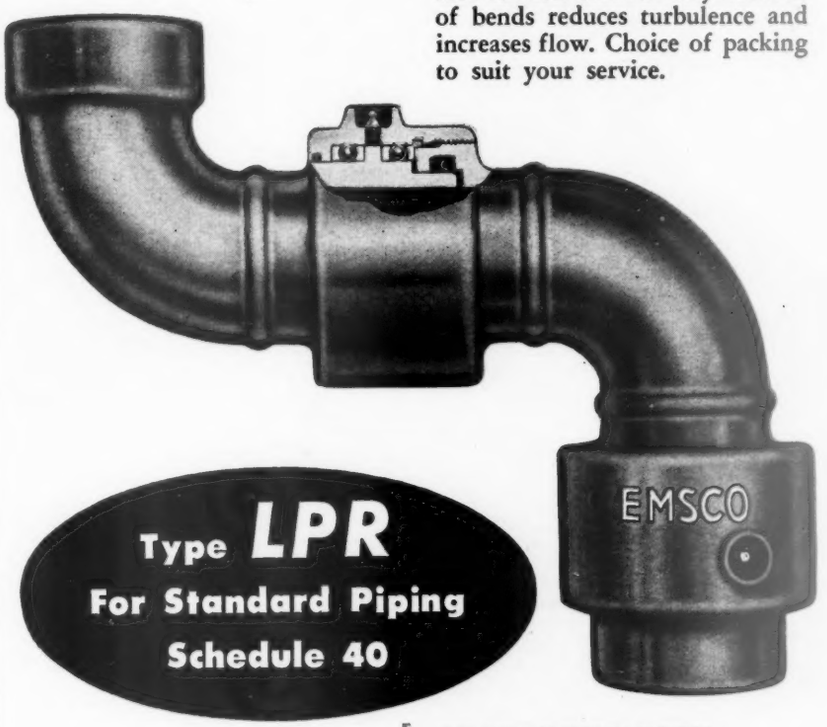

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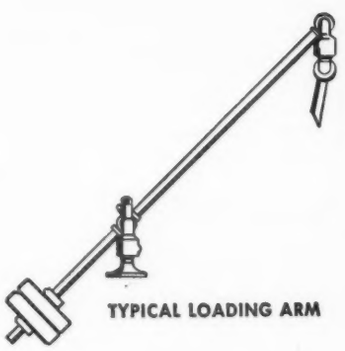

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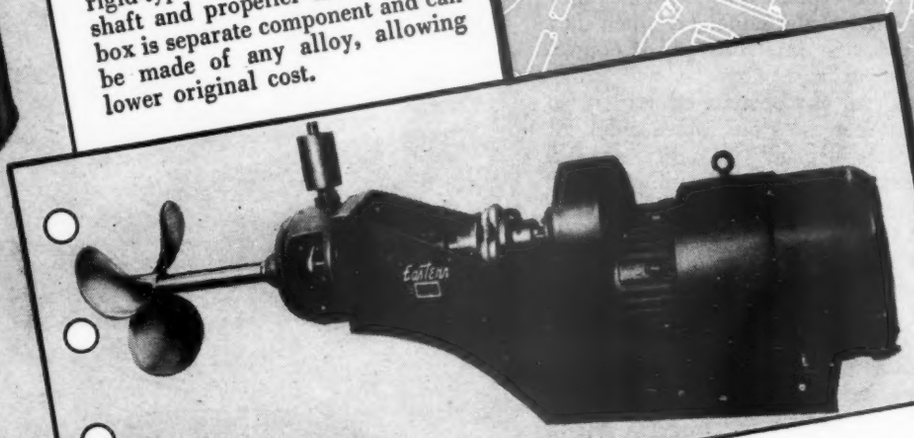

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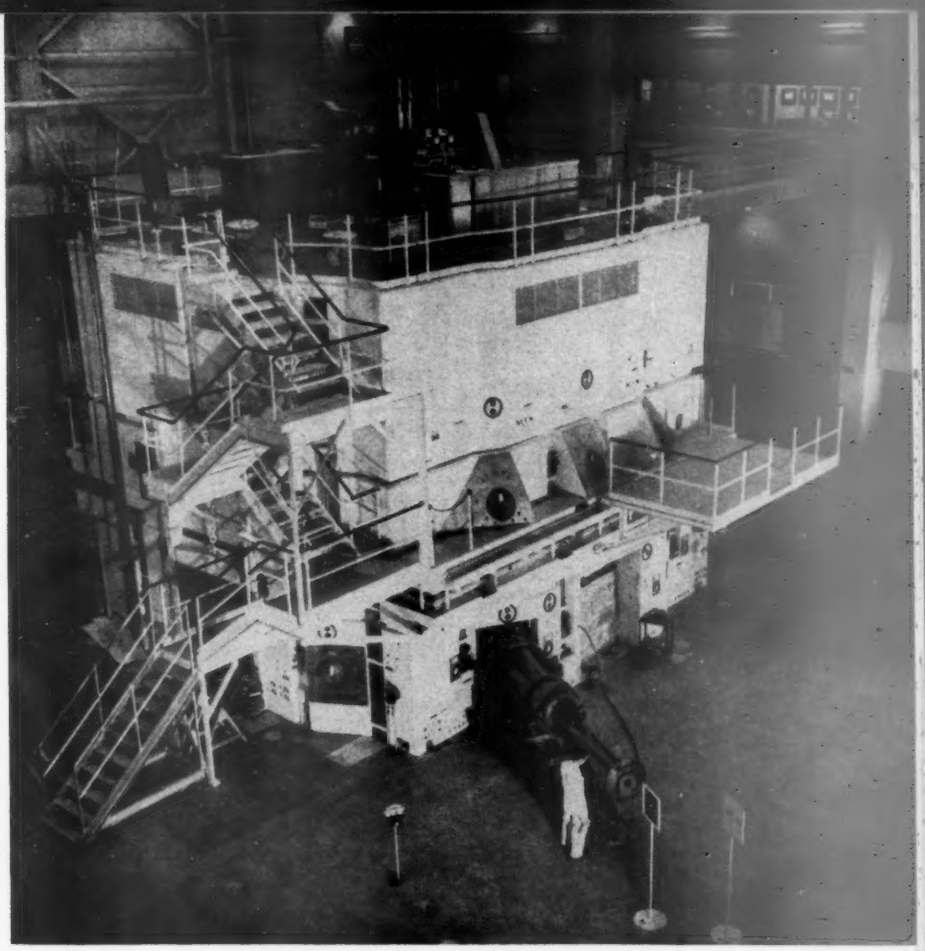


Materials testing reactor operated by Phillips for Atomic Energy Commission near Idaho Falls, Idaho. Artillery-shaped equipment in foreground is device used in insertion of experiments into reactor. Control room is in right background.

Peacetime possibilities of atomic energy will be more thoroughly developed with opening of facilities by the Atomic Energy Commission to qualified research organizations equipped to handle radioactivity safely.

Atomic Energy Testing Reactor Open to Private Companies

SPECIALIZED facilities of the materials testing reactor operated by Phillips Petroleum Company for the Atomic Energy Commission has been made available to the public on a limited basis.

Phillips began as atomic energy contractor in 1950 when it was selected by the Commission to operate the MTR west of Idaho Falls. Uranium is "burned" in this reactor is such a way as to produce the world's highest known nuclear radiation intensity. Experiments in the effects of this intense radiation on various materials provide new scientific data essential for use in many fields, according to Phillips.

The company's atomic energy assignments were enlarged last year, when Phillips was named by the Commission to extend its supervision to the Idaho chemical processing plant and many other functions at the national reactor testing station.

The materials testing is a unique research tool because it is a high intensity neutron source. It can produce isotopes of higher specific radioactivity than the Argonne, Brookhaven, and Oak Ridge reactors, and a part of these facilities will be available to the public, the U. S. Atomic Energy Commission reports.

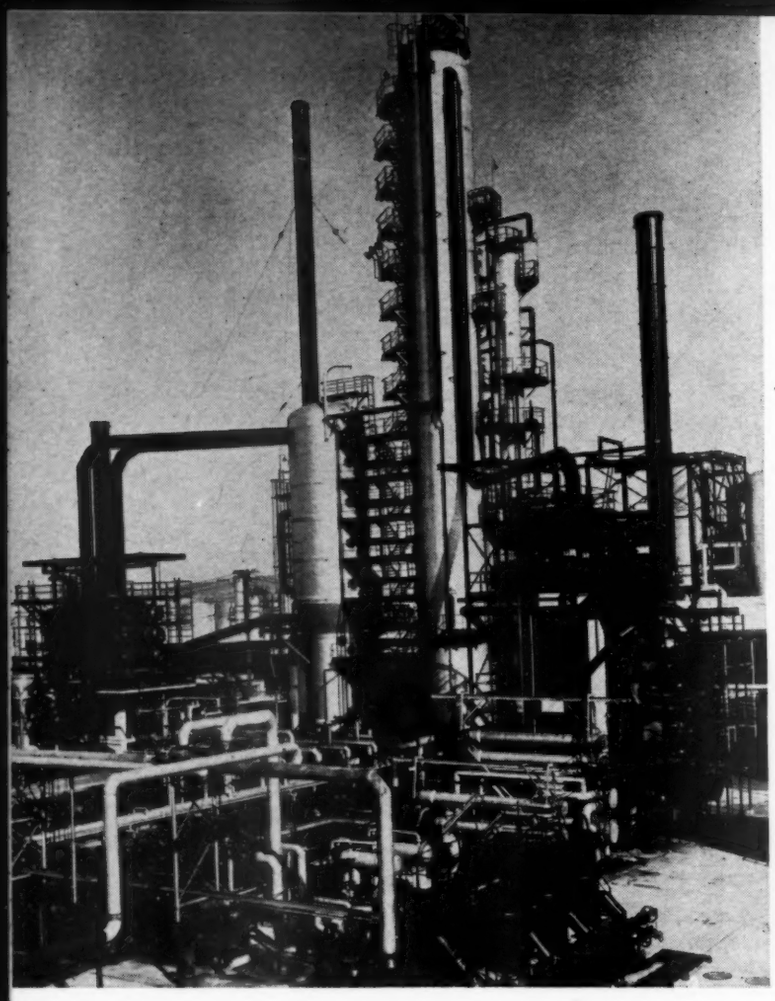
Even portions of the area of the reactor's greatest neutron intensity, used primarily for AEC projects, may be available from time to time, however, requirements of the atomic energy program will take precedence over non-government experiments in all areas of the reactor. Because of security considerations experiments requested by the public will be performed by Phillips.

The reactor was designed and constructed as a pioneer step in the development of high neutron intensity reactors and with the primary purpose of providing facilities to test materials that would be used in future reactor construction.

Charges will be made for public irradiations in the MTR. Based on all costs involved, including depreciation, overhead, and operating expenses, charges are considered to be sufficiently low to bring the service within the means of qualified research organizations, AEC reports. Applications should be filed with the U. S. Atomic Energy Commission, Isotopes Division, Oak Ridge, Tennessee, who will issue authorizations to persons or firms equipped to handle radioactivity in a safe manner. Phillips, Idaho Falls, Idaho, should be contacted directly for information concerning technical questions relating to irradiation services, scheduling, price lists, etc.

In commenting on the Atomic Energy Commission's recent announcement, K. S. Adams, chairman, and Paul Endacott, president, Phillips Petroleum Company, stated "we are pleased with the Commission's decision to make available for private research and industry certain experimental services of the materials testing reactor. The progressive developments of the Commission in the direction of industrial use of atomic energy hold great possibilities for peacetime public benefit.

"With the new public service offered through the materials testing reactor," the Phillips officials added, "our company should now be in a position to do even more to further the Atomic Energy Commission's aims of utilizing more fully the benefits from atomic energy developments." * * *



Typical modern crude battery at Standard of California's Richmond, California, refinery, depicting increasing complexity of refinery processes during the company's 75-year history. Below, is an old Standard tank wagon truck, which was the pride of the company's truck fleet in the early 1900's.

P 099.

Standard of Cal Grows 1400 Times in Its First 75 Years

STANDARD Oil Company of California will observe its 75th anniversary on September 9 of this year.

The company traces its lineage to both the original Standard Oil Company and the first California oil industry, and dates its corporate history from the founding of Pacific Coast Oil Company in 1879.

Pacific Coast Oil was later purchased by Standard Oil interests and, in 1906 merged with Standard of Iowa, creating what we now know as Standard Oil of California.

But the company that bears the name today is a far cry from the small firm that brought in California's first successful well in 1876. It flowed 30 bbl a day — today, the company's U. S. output totals almost 125,000,000 bbl a year from 7000 wells. Its share of affiliates' production in the eastern hemisphere totals 100,000,000 bbl annually.

Refining

That same year, 1876, a predecessor company built California's first refinery, at Newhall. With its principal output of kerosine and grease, the refinery's capacity was 22,000 bbl annually. Today, Standard and its wholly-owned subsidiaries operate six major refineries in the U. S. with a combined capacity of 150,000,000 bbl annually, and they manufacture more than a thousand products.

Pipe Lines

Two years after California's first well was brought in, the state's first pipe line was laid — a total of seven miles long. Constructed by a Standard predecessor in 1878, the line hardly compares with the hundreds of miles of pipe line Standard of Cal and its subsidiaries maintain across eight western states, today, with an interest in pipe lines in Arabia and Canada.

Research

During its 75 years of growth, Standard of California has been one of the leaders in the search and discovery of new uses for petroleum products and better ways to use them. California Research Corporation, which is the research branch of the company, employs a thousand people, of whom half are scientists and technicians.

Financial Position

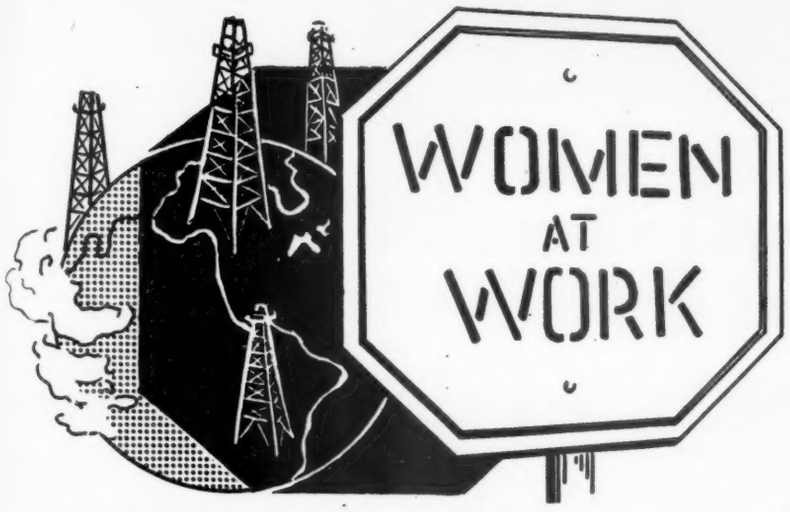
When Pacific Coast Oil Company was established in 1879 it had capitalization of about a million dollars. Five years later it was selling $35,000 in petroleum products annually.

Net worth of the company today is more than $1.4 billion, and net earnings are over $170,000,000 yearly.

Future Expansion

Standard of California continues to maintain a policy of planned expansion. In the budget for the current year, approximately $275,000,000 has been earmarked for capital and exploratory purposes.

Nearly two-thirds of the total, or about $175,000,000 will be spent to find new oil reserves and for the development of production in existing fields. The balance will be spread throughout other operations. * * *



Husband-Wife Partnership

The letterhead **"P. A. Knupp — H. V. Knupp**, Petroleum Geologists," is somewhat misleading (as it, perhaps, was intended to be!) for the P. A. part of this partnership is a petite female whose love of geology is topped only by her love for the other half of the partnership, Hal Knupp, and their two little girls, Kathy and Margaret.

This unusual combination flourishes in Denver, Colorado, at 12625 East 13th Avenue, which is both business and home address for the oil-minded Knupps.

Patricia studied geology at the University of Kansas, took her B.S. and stayed for a year and a half of graduate study. During the last 18 months she collected a membership in the Society of Sigma Xi, and Hal, a fellow graduate student. The young couple moved to Sterling, Colorado, where Pat did special jobs of subsurface contouring and geologic drafting. Her husband, a geologist with British American Oil Producing Company, took her along occasionally to sit a well and learn all phases of the oil business. A transfer for Hal took them to Denver. Patricia followed his work and continued hers.

In 1953 Hal and Pat Knupp took the plunge they'd planned along with their wedding. He resigned his job and they announced their partnership.

H. V. Knupp manages the field work and the downtown work. P. A. Knupp handles the office, does subsurface mapping and writes geologic reports. Together they do geologic evaluating of prospective drill sites, write reports on oil prospects and work up drilling prospects of their own. Their work centers in the Denver-Julesburg Basin.

Their work and their hobbies are so closely connected that it is impossible to tell where one stops and the other begins. Three-year-old Kathy and eight-month-old Margaret they sometimes refer to as their favorite hobbies, yet the little girls are a big part of their partnership. They enjoy camping, but this always includes hard rock prospecting, which is back to business again!

Kansas Geology Expert

The ink was hardly dry on **Shirley Lenderman's** B.S. in geology from the University of Michigan when she went to work for Stanolind Oil and Gas Company in Wichita, Kansas, in 1944. This month, as she marks her tenth anniversary with the company, she is recognized as an expert on Kansas subsurface geology.

Shirley Edmands Lenderman brought a colorful background to the oil industry. Born in the Philippine Islands, she spent her childhood on various military posts. In June 1941, the Edmand's family was evacuated from Ft. William McKinley, Philippines, leaving her father, Col H. J. Edmands, U. S. Army, behind. Shirley spent the war years in college. Two days after her graduation she signed in at Stanolind.

Tragedy had a hand in giving Shirley the patience and serenity her job requires. Her father, a Japanese prisoner of war, was killed at Christmas 1944. She was married in 1945, and divorced soon afterward. In 1949 she was stricken with infantile paralysis and spent long painful months recuperating before she could return to her desk at Stanolind.

Bright note in these tragedies was the birth in April 1946 of Jane Lenderman, Shirley's daughter.

"Jane is my biggest hobby," Shirley says. The two live in an inherited stone house, one of Wichita's earliest, which lends itself to Shirley's love of and training in interior decorating.—"Some of its rooms are intriguing problems!"

Shirley belongs to the Kansas Geological Society, AAPG.

Pretty, patient and popular, Shirley knows she's well off—"With a career that challenges my ambition, a house that tests my ingenuity, and a daughter who makes it all worthwhile."

Patricia Knupp combines her business with hobbies.

Shirley Lenderman is an enthusiastic geologist.

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There is no other hose on the market that can match H-1515's contribution to oil transportation.

HERE ARE THE FACTS:

1. Weighs 2/3 less than conventional hose.
2. End fittings weigh 50% less.
3. Used by every major oil company. It has been tried and proven by up to 3 years' service.
4. More than 800 lengths of U. S. Amazon H-1515 now in service.
5. Its light weight eliminates accidents that occur with the handling of heavy hose.
6. Requires less manpower or mechanical handling devices to make connections for loading or unloading.
7. Instantly springs back to shape if crushed or folded.
8. It handles 200 pounds working pressure.
9. Dock workers are outspoken in praise of its lightness and ease of handling.
10. It is indispensable for hard-to-reach bunkering headers. Connections are made without the use of a hoist.
11. No further proof or trial is required to establish its superiority.
12. Easily transported—can be coiled or folded on truck or other vehicle for moving between locations.

More than 800 lengths of U. S. Amazon® H-1515 Oil Discharge Hose have been put into active service from coast to coast in the short space of 3 years—the superiority of this great hose has been proven and accepted beyond question. U. S. Amazon H-1515 is made only by United States Rubber Company and sold through any one of the 27 "U. S." District Sales Offices. Further information is obtainable by writing the address below.

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"U. S." Production builds it.
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Prefers "sitting on wells" to dancing.

Heads Oil Women's Group

The 375-member Oil Secretaries Association in Wichita, Kansas, is the only club in which **Bee Kooken** holds active membership. And it's enough. She is its president.

For the past 12 years Mrs. Kooken has been an oil woman as executive secretary to independent oil man, W. L. Hartman. She is in charge of legal work and is office manager in addition to her secretarial duties.

A native Kansan, she took popularity and scholastic honors in both high school (at McPherson) and business college (in Wichita) before she went to work with the Federal Land Bank. Soon afterward she switched to oil.

As head officer of the Oil Secretaries group, Bee finds most of her time well occupied but still pursues her favorite hobby — sitting on "drilling-in" wells. Having been in both the geological and production ends of the business, finding oil fascinates her, and she is one woman who prefers field trips to social functions.

The association, first organization of its kind in the United States, was organized in 1938. Its membership makes at least one annual field trip to a drilling well; they have an annual bosses' night; last year they initiated a bosses wives' night that proved so popular they plan to make it an annual affair. As a group they do Red Cross solicitation, and from club funds they annually contribute to four selected charities. During Oil Progress week they make posters, plan and decorate windows; distribute literature, stickers and pins, and plan an annual Oil Coronation ball.

In addition the club functions as an employment agency for the oil industry.

Boyd Kooken might object to his wife's numerous activities if he were not also an oil enthusiast. He works for John P. Gaty, independent oil operator.

Some day the Kookens plan to be independent oil people themselves.

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PERSONALS

C. L. Dretzke has been appointed personnel assistant of the Great Northern Oil Company. He will supervise the selection and training of office and plant personnel for a new plant at Pine Bend, Minnesota. A graduate of River Falls State College, Dretzke was office and personnel manager for the Northwestern refinery of Saint Paul Park until his recent appointment.

Elmer F. Schmidt, senior vice president in charge of transmission of Lone Star Gas Company, resigned effective June 1 to enter gas consulting work. The offices of his new business are in the Landa Building at 5738 North Central Expressway, Dallas, Texas.

Schmidt was with Lone Star 36 years, having joined the organization in 1918 as head of the gas measurement department.

Elmer F. Schmidt

His advancement since then has been steady. In 1919 he was made chief engineer, in 1920 general superintendent, in 1935 was elected to the board of directors, in 1936 vice president, in 1937 vice president and operating manager, and in January, 1946, senior vice president in charge of transmission.

A graduate of Cornell University, Schmidt worked for Ohio Fuel Supply Company and Fayette County Gas Company before joining Lone Star.

Schmidt's retirement, coupled with expansion of the company, have resulted in a number of personnel changes, which are as follows:

John M. Kindle has been advanced to superintendent of operations. **Thomas S. Bacon,** transmission division chief engineer, will continue in this capacity with expanded duties; **Chester R. Rogers** has advanced to superintendent of gasoline plants. **Carl M. Hill** becomes superintendent of operations. **M. O. Attebery** was named superintendent of production. **Gerdes Rice,** superintendent of right-of-way and claims, has been transferred to the transmission division from the land department.

E. L. Harpold has been named supervisor of stores and **Arthur L. Williams** has assumed duties as assistant supervisor of stores.

Harpold joined the company in 1920. He was transferred to Dallas in 1926 and became assistant supervisor of stores in 1930.

Williams joined the company as a warehouseman in 1925, and was promoted to storekeeper there the following year. He moved to Ranger as storekeeper in 1932. He was named field supervisor for the department with headquarters in Dallas, at the time of his promotion.

F. M. Jayne

H. G. Vesper

Fred E. Woodring

F. M. Jayne has been elected vice president of Standard Oil Company of California. Jayne joined Standard as a clerk at the Richmond refinery in 1934. He is a graduate of the University of California and has a M.A. in business administration. Jayne was appointed assistant comptroller in 1947 and two years later was made secretary of the executive committee.

Howard G. Vesper, vice president of Standard of California, is the new president of the Industrial Research Institute, Inc. Vesper, a graduate of California Institute of Technology, has been with Standard of California since 1922.

E. D. Reeves was elected vice president, succeeding Vesper. Reeves automatically succeeds to the presidency in 1955.

New members of the board of directors are: **Warner Eustis,** The Kendell Company; **F. W. Stavely,** Firestone Tire and Rubber Company, and **R. E. Birch,** Harbison-Walker Refractories Company.

Robert H. Colley, chairman of the board of The Atlantic Refining Company since 1952, has retired from the company. He will continue as a member of Atlantic's board.

Colley, who started with Atlantic in 1919, was elected president in 1937. In 1952 he was succeeded as president by Henderson Supplee, Jr., and was elected chairman of the board.

E. O. Vetter has been appointed assistant vice president, administration, for Geophysical Service, Inc. He heads a newly organized administrative division set up to coordinate GSI staff functions and to consolidate activities of the company's control and equipment departments. Vetter, a graduate of M.I.T., joined the staff of GSI as controller in 1952.

H. H. West has been elected a vice president of The Ohio Oil Company. He is secretary and a director of the company.

An employee of The Ohio Oil Company since 1922, West first served as a stenographer in the general office. In 1926, he became secretary to former President O. D. Donnell who was then treasurer.

Fred Powell has been appointed assistant general manager of Standard Oil Company of California's manufacturing department. Powell, who joined the company in 1925, previously headed the subsidiary, California Research and Development Company, which has been dissolved following completion of its assignments for the Atomic Energy Commission.

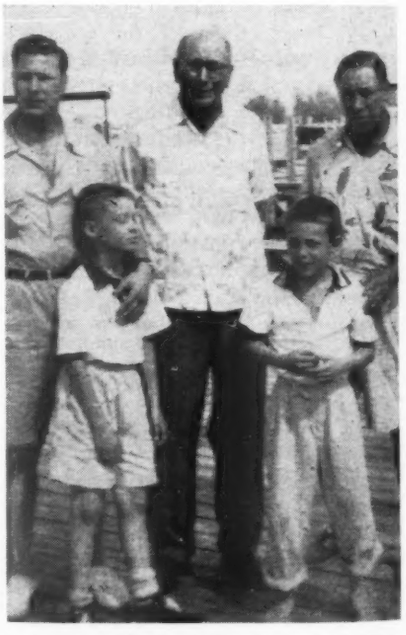
A graduate of the University of Washington, Powell was general manager of the El Segundo plant, until his appointment as president of CR&D in 1950.

Fred E. Woodring has been named executive vice president of the Rocky Mountain Oil and Gas Association. A graduate of the University of Pennsylvania, Woodring was formerly traffic coordinator for Sun Oil Company. He was executive secretary of the Wyoming Trucking Association when he accepted the RMOGA appointment.

Earl B. Baldridge has been elected president of the Chicago Corporation. He succeeds **Richard Wagner** who became chairman of the board and chief executive officer. Baldridge is president of Champlin and chairman of the board of Peppers, two refining companies recently purchased by Chicago.

Charles B. Johnson, Jr., is vice president in charge of production operations and **Ira H. Stein** is vice president of land and exploration.

P. R. Wrigley has been appointed to the Western Petroleum Refiners Association industrial relations department. A graduate of the University of Oklahoma, Wrigley was formerly employed by the Rock Island Railroad.



Four generations of Slagters—A. J. Slagter, III, back row, chief geologist and petroleum engineer, Slagter Producing; A. J. Slagter, who built first oil refinery in Japan while with Shell 45 years ago, died April 25; A. J. Slagter, Jr., president, Slagter Producing; front, A. J., IV, and Philip, sons of A. J., III, who hopes they will enter the oil business some day.

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Personals

International guests at April 14 Los Angeles Nomads meet were: Standing, Leo Goss, Santa Fe Drilling; Eugene M. Bandy, Socony-Vacuum; Jorge Gromsch, Empresa Nacional del Petroleo Chile; Bob Halpert, Socony-Vacuum; Roy Pratten, Socony-Vacuum; Patricio del Solar, Empresa Nacional del Petroleo Chile; (seated), Frank Gess, Santa Fe Drilling; J. J. Parks, Mene Grande Oil; V. B. Davis, Empresa de Colombia; Karl Jauman, Iraq, and Marshall C. Graham, Mosul Petroleum, Iraq.

Louis W. Shank has been promoted to suggestion system manager of Ethyl Corporation.

A new suggestion system which he will direct will become effective June 1 throughout the company.

Shank, a graduate of Johns Hopkins, has filled several executive positions in the sales department. He was assistant to the vice president in charge of sales before his appointment.

Gervais F. Favrot has been appointed to the Board of Directors of United Gas Corporation. President of Gervais F. Favrot Company, Inc., Favrot is know in construction circles in New Orleans and elsewhere in the South.

He has also been active in civic work in New Orleans.

Paul H. Le Fevre has been elected an assistant treasurer of Socony-Vacuum Oil Company, Inc. He joined the company in 1928 as a member of the foreign accounting staff. Later he served in the comptroller's department and in positions with the company's operations in South America. In 1952 he was named treasurer and controller of Socony-Vacuum Overseas Supply Company with headquarters at Fort Lee, New Jersey. Fevre is a graduate of New York University.

Earl W. Beck has been named general purchasing agent. Beck joined General Petroleum Corporation, Socony-Vacuum's affiliate on the West Coast, in 1923. He became manager of purchases for that company in 1937 and in 1946 was made assistant general purchasing agent for Socony-Vacuum.

N. B. Sauve, former chief geophysicist, Standard-Vacuum Oil Company, has been elected a director of Vacuum Oil Company, Ptv., Ltd., Melbourne, Australia. He also has been appointed general manager of the Frome-Broken Hill Company. Pty., Ltd., an exploration company under Vacuum's technical management. Sauve joined the company in 1934, following oil exploration experience in the United States and South America.

Morris M. Slotnick has joined the company as geophysical consultant and advisor for the company's exploration activities in the far east. He was with Humble as chief mathematician before his new appointment. A Harvard graduate, Slotnick is a former editor of *Geophysics.*

Emory N. Kemler, professor of mechanical engineering and head of the machine-design and instrumentation division of the Institute of Technology, Universtiy of Minnesota, has been elected a Fellow of The American Society of Mechanical Engineers. According to "Mechanical Engineering," Official publication of the society, Kemler is a "widely known research and production engineer in the petroleum and other fields."

V. R. Tomlinson has been appointed counsel of Sinclair Refining Company, subsidiary of Sinclair Oil Corporation. Tomlinson, who has been general attorney of Sinclair Refining Company since 1946, joined its legal department in 1926 in the Chicago office.

E. C. Peet, vice president in charge of finance, has been named a member of the board of directors of Shell Oil Company. Peet, a graduate of the University of St. Louis, joined Shell in 1919 as a clerk. After serving as manager of the auditing department in San Francisco, he moved to New York in 1940 as assistant secretary and assistant treasurer. He was appointed vice president and treasurer in 1944 and senior financial officer of the company in 1949.

J. R. C. Boyce has been appointed secretary and treasurer of Trinidad Leaseholds (Canada) Ltd. He joined Trinidad Leaseholds, Ltd., in 1930.

Jack Cox has been named assistant to the president of Southern Minerals Corporation. He was State Representative from Breckenridge before joining the company in 1953. **Jenks Smith** has been appointed assistant vice president. He was formerly in the land department.

Dr. Kieffer Davis, medical director, Phillips Petroleum Company, was recently elected president elect of the Industrial Medical Association. Davis joined Phillips in 1947 as head of the company's medical department. He was among the first in industry to use a mobile medical unit as a means of reaching field employees for periodic health determinations.

The Industrial Medical Association is a world-wide organization of physicians primarily interested in health and medical problems related to industry.

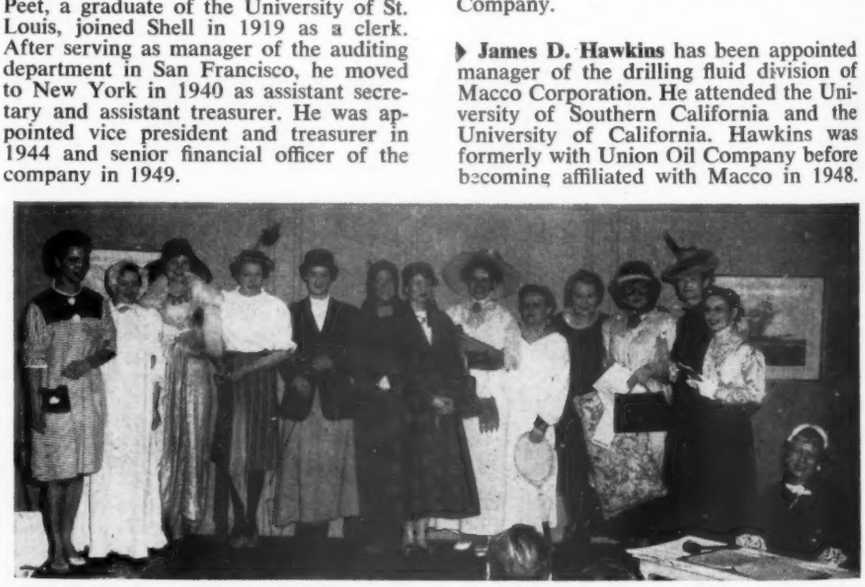
Robert L. Milligan, director of American Petroleum Institute, has been named president of Pure Oil Company, succeeding **L. S. Wescoat** who advances to chairman of the executive committee. Milligan joined the company in 1929, and was formerly assistant secretary-treasurer.

J. Porter Langfitt, senior vice president, has been promoted to executive vice president, succeeding Milligan. Langfitt was formerly head of research and development, engineering and patent activities. He has also been in charge of the company's refineries.

Frank A. Morgan, vice president and manager of exploration of Richfield Oil Corporation has resigned his position. He announced no immediate plans for the future, but reports he intends to stay in the oil industry.

Morgan has served as vice president and exploration chief of Richfield since formation of the company in 1937. Prior to that he was with Rio Grande Oil Company.

James D. Hawkins has been appointed manager of the drilling fluid division of Macco Corporation. He attended the University of Southern California and the University of California. Hawkins was formerly with Union Oil Company before becoming affiliated with Macco in 1948.



Los Angeles Desk and Derrick Club members entertained the L. A. Chapter of Nomads with a humorous skit at their April 14 meeting. Girls, in costume for their skit, are: Eleanor Murphy, Union Oil; Ruth Stine, Signal Oil and Gas; Lucille Lyle, Bankline Oil; Billie McKee, General Petroleum; Marjorie Marsh, Bankline Oil; Mildred Taylor, Signal; Virginia Henson, American Bitumuls and Asphalt; Ethel Beyer, Pathfinder Petroleum; Dorcas Launer, Security Engineering; Kate Binney, Oceanic; Ardys Cook, Beloil; Trella Gorman, Union Oil; Lois Watson, Bell Petroleum, and Blanche Kelley, Union Oil.

Franklin E. Bernsen, president of Lucey Products Corporation, has been elected a director of Sterling Oil of Oklahoma, Inc. Other directors elected were: **Arthur G. Bisgood,** president of Registrar and Transfer Company; **Albert F. Donohue**, Kidder, Peabody and Company; **Albert Barnes Zink**, Zink, Shinehauser and Holmes, Estes, Zink and Tait, accountants and tax specialists, and **Frank Zugelter,** Zugelter and Zugelter, patent and trade-mark specialists.

Paul M. Fluckiger has been appointed special field service representative of the Pennsylvania Grade Crude Oil Association for the Pacific Coast area. He succeeds C. R. Wheeler. Fluckiger was a claims adjuster for Traders and General Insurance Company in its Los Angeles offices, before accepting his new position.

Norman L. Kimes, Jr., has been appointed special field service representative in the Mid-West area. Before his appointment he was assistant manager of an Oil City, Pennsylvania, service station. Kimes attended Slippery Rock State Teachers College.

Edward H. Salrin has retired after 40 years of service with Tide Water Associated Oil Company and its predecessor companies. For the past 20 years he has served as vice president and director of Tide Water Associated and chairman of the operating committee of the Mid-Continent division.

Salrin was president of the Tidal Oil Company when it was consolidated with Tide Water.

Irving E. Chapman will replace **Edward P. McCall** as vice president and director of Mitsubishi Oil Company, Ltd. Tide Water has a 50 per cent interest in Mitsubishi.

Chapman, a graduate of Stanford University, has been with Tide Water since 1928. He was formerly assistant manager of operations of the western sales division.

Richard P. George has resigned as regional superintendent for the International Petroleum Company, Ltd., in South America, to become associated with M. "Bink" Manning, Inc., and M and R Specialty Company. He was employed by Phillips Petroleum Company and several drilling contractors prior to joining International Petroleum.

Herman A. Metzger is new director and vice president in charge of Creole Petroleum Corporation's New York office.

Metzger was graduated from Cornell University in 1921 and that same year joined International Petroleum, Standard of Jersey affiliate. He was head of Jersey's affiliates in Argentina and Paraguay, until his transfer to Creole.

The Facts Belie the Charges

"Belying the unfair but often repeated charge that the oil business is

a monopoly or a series of monopolies, these are the facts: The industry includes more than 12,000 separate and independent crude oil producing enterprises, companies, and individuals. While the major oil companies look for oil and produce a lot of it, it is the independent producers who, on the basis of past history, drill about 80 per cent of the wildcat wells.

"There are over 600 natural gasoline plants, the ownership of which is most widely disseminated. There are over 400 refineries owned by 207 different companies. Also, there are 243 separate manufacturers of lubricating oils and greases.

"There are 5500 separate enterprises engaged in the distribution of liquefied petroleum gas and over 11,000 fuel oil dealers. There are over 179,000 separately owned service station businesses. Almost all of the drilling of oil wells for both independent producers and larger oil companies is carried out by independent drilling contractors.

"There are hundreds of separate companies engaged in petroleum transportation—specifically, there are 54 pipe line companies, 42 tanker companies, 174 barge lines, and 1063 for-hire truckers.

"The oil business is not a monopoly and anyone is free to enter it. Doctors, lawyers, grocerymen, and entrepreneurs do enter it each year and the smart ones thrive."—*Bruce K. Brown, president, Pan-Am Southern Corporation.*

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OUTSIDE AND INSIDE

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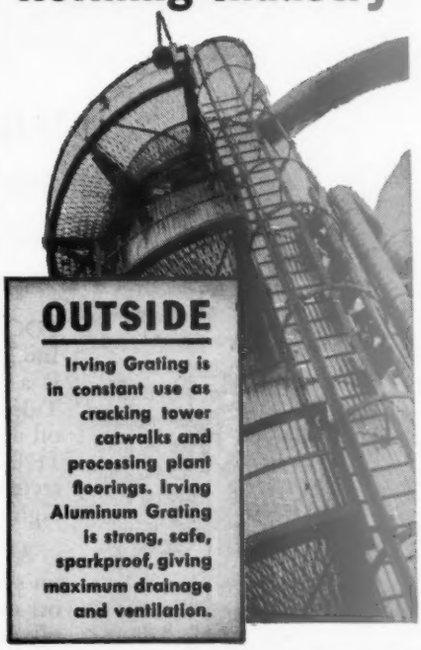

OUTSIDE

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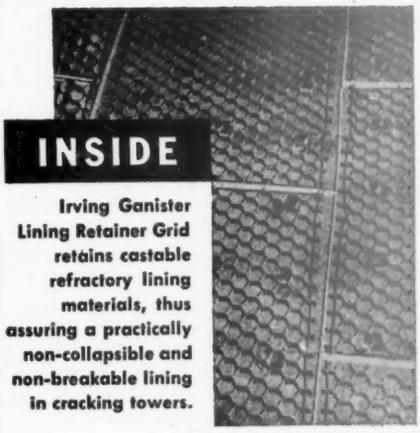

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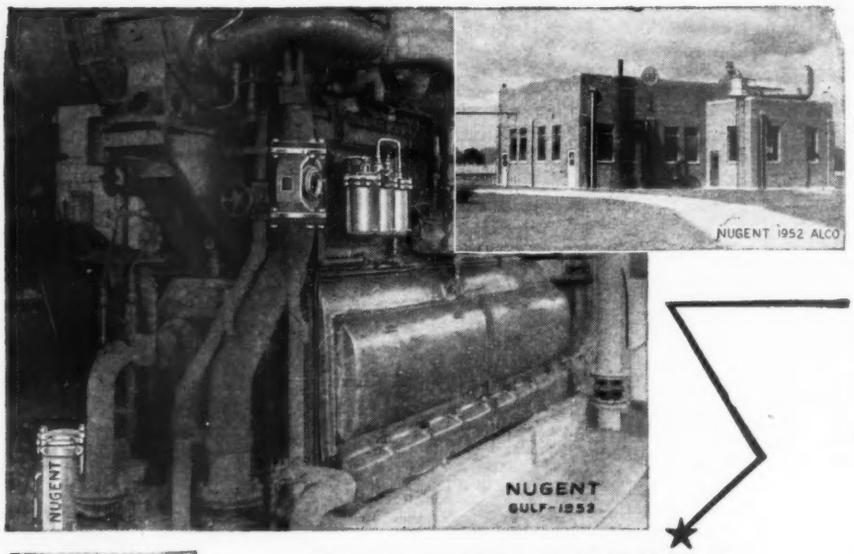
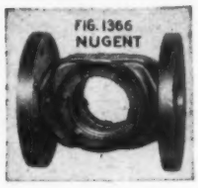
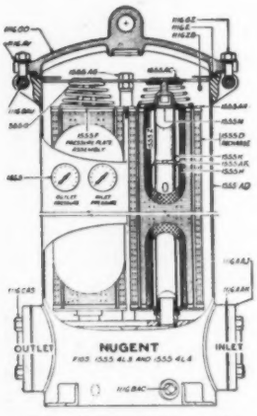
ESTABLISHED 1902

OFFICES and PLANTS at
5052 27th St., Long Island City 1, N. Y.
1852 10th St., Oakland 20, California





Nugent Sight Flow Fitting. Shows flow of water to the jackets.



Size #4L4 Engine Lube Oil Filter.

Nugent Duplex Fuel Oil Filter.

NUGENT FILTERS
HANDLE THE COMPLETE JOB on this 1170 H.P. Pumping Station Diesel

LOCATED at Stateline Station, Union City, Ind., the 8 cylinder Alco diesel illustrated is a vital cog in the Gulf Oil Company's Tulsa-Lima Pipe Line. That's why the fuel oil and the entire lubrication system of this 1170 H.P., Turbo-charged engine is protected by Nugent filters and a Nugent Sight Flow indicator.

A Nugent #1R Duplex Fuel Oil filter on suction of fuel pump and Nugent #1R on discharge of fuel pump keeps the fuel oil clean for trouble-free injection — a Nugent #4L4 Engine Lube filter cleans all the engine lube oil in circulation every cycle before going to the bearings. A Nugent Sight Flow indicator provides a visual check on water flow to the jackets.

By actual test, Nugent filters remove particles as small as a few microns and prevent them getting to where they can accelerate wear and tear and shorten engine life. In addition Nugent Filters offer a choice of full flow or by-pass filtering with the same unit. Recharges are inexpensive and easy to install. Simple piping makes installation no problem.

Write for descriptive literature that shows how to insure the long life of your diesel.

Wm. W. Nugent & Co., Inc.
41c N. Hermitage Ave. CHICAGO 22, ILLINOIS

OIL FILTERS, OILING AND FILTERING SYSTEMS, TELESCOPIC OILERS, OILING DEVICES, SIGHT FEED VALVES, FLOW INDICATORS
Established 1897
Representatives in Boston • Cincinnati • Dallas • Houston • La Junta, Colo. • Los Angeles • Minneapolis • New Orleans • New York • Philadelphia • Portland, Ore. • San Francisco • Seattle • St. Louis • Tulsa • Representatives in Canada: Montreal • Toronto • Vancouver

DEATHS

F. W. Wilkening, founder and chairman of the board of directors of Wilkening Manufacturing Company, died Thursday, April 22, 1954.

Francis W. Little, assistant area manager for the Oil Well Supply Company in Dallas died Wednesday, April 22 at his home. He had been with the company 25 years.

G. T. Van Alstyne, director of advertising and publicity, Air Reduction Company, Inc., died April 21, 1954 at his home in Plainfield, New Jersey. He had been ill since December. Alstyne joined Airco's advertising department in 1919. In 1931, he was appointed advertising manager for Air Reduction Sales Company, a post he held until 1952, when he became director of advertising and publicity for Airco.

Edgar F. Schaefer, president of the Gardner-Denver Company, died suddenly at his home in Quincy, Illinois, May 2. A graduate of the University of Illinois Schaefer joined the Gardner-Denver Company in 1919, as cost clerk. Through rapid promotions, he became export manager and then assistant sales manager. In 1926 he was made vice president in charge of sales and was named as a member of the Gardner-Denver board of directors. He was elected executive vice president in 1942 and became president five years later.

Sherman N. Shumway, vice president and director of the Signal Oil and Gas Company, died from a heart attack at Soboba Hot Springs, California. A graduate of Boudoin College and Harvard Law School, Shumway joined the company ten years ago. Prior to that time, he was president of the Merrill Trust Company of Bangor, Maine.

Harold R. Pauley, president of the Stancal Asphalt and Bitumuls Company, died May 7 of a heart attack. A graduate of Stanford University, Pauley was in the oil business most of his life and was formerly president of the Petrol Corporation.

Emmert G. Surber, refinery superintendent of the General Petroleum Corporation refinery at Torrance, California, died May 16. Surber had been in refining work with General Petroleum for 31 years. He joined the company immediately after leaving the United States Navy at the end of World War I.

Charles R. Crane II, vice president and director of Crane Company, died suddenly May 8 at his home in Chicago. A grandson of Crane's founder, Crane was associated with the company for 46 years. He began as an apprentice molder at the company's Chicago factory. At the time of his death Crane had supervision over the executive policy of the company's subsidiary in England.

F. C. Hall, independent producer, died recently in Oklahoma City. He entered the oil business in the Chickasha and Cement fields in Oklahoma, and later was active in the Oklahoma City field and in West Coast fields.

Sylvester Yunker, Owensboro, Kentucky, independent producer, died recently following a stroke. He entered the oil business in 1934 and was one of the first to introduce water flooding in the Owensboro area. Yunker had been the state's representative on the Interstate Oil Compact Commission.

UNIVERSAL CONVERSION FACTORS

CUBIC FOOT PER DAY (Continued)

0.00034633	quarts per second
28.317	liters per day
1.17988	liters per hour
0.019664	liters per minute
0.00032774	liters per second
28.317	cubic decimeters per day
1.17988	cubic decimeters per hour
0.019664	cubic decimeters per minute
0.00032774	cubic decimeters per second
59.84515	pints per day
2.49354	pints per hour
0.041559	pints per minute
0.00069265	pints per second
239.38060	gills per day
9.97416	gills per hour
0.166236	gills per minute
0.0027706	gills per second
283.17	deciliters per day
11.79875	deciliters per hour
0.19664	deciliters per minute
0.0032774	deciliters per second
1,727.98829	cubic inches per day
72.0	cubic inches per hour
1.20	cubic inches per minute
0.020	cubic inches per second
2,831.7	centiliters per day
117.98750	centiliters per hour
1.9664	centiliters per minute
0.032774	centiliters per second
28,317	milliliters per day
1,179.8750	milliliters per hour
19.664	milliliters per minute
0.32774	milliliters per second
28,317	cubic centimeters per day
1,179.8750	cubic centimeters per hour
19.664	cubic centimeters per minute
0.32774	cubic centimeters per second
28,317,000	cubic millimeters per day
1,179,875	cubic millimeters per hour
19,664	cubic millimeters per minute
327.74	cubic millimeters per second

CUBIC FOOT PER HOUR =

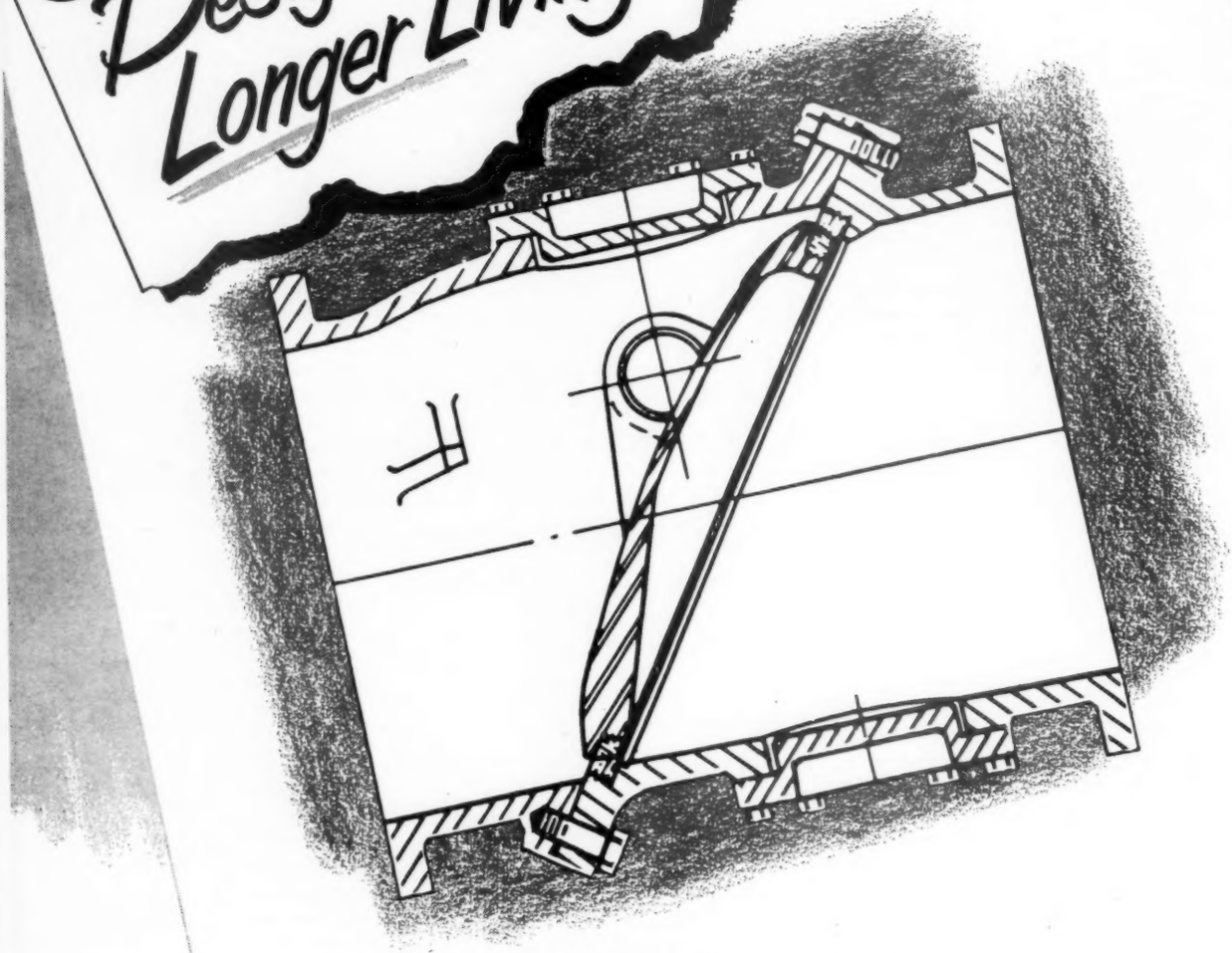
4.27464	barrels per day
0.17811	barrels per hour
0.0029685	barrels per minute
0.000049475	barrels per second
0.67961	kiloliters per day
0.028317	kiloliters per hour
0.00047195	kiloliters per minute
0.0000078658	kiloliters per second
0.67961	cubic meters per day
0.028317	cubic meters per hour
0.00047195	cubic meters per minute
0.0000078658	cubic meters per second
0.88888	cubic yards per day
0.037036	cubic yards per hour
0.00061728	cubic yards per minute
0.000010288	cubic yards per second
6.79605	hectoliters per day
0.28317	hectoliters per hour
0.0047195	hectoliters per minute
0.000078658	hectoliters per second
24	cubic feet per day
1	cubic feet per hour
0.016667	cubic feet per minute
0.00027778	cubic feet per second
67.96051	dekaliters per day
2.8317	dekaliters per hour
0.047195	dekaliters per minute
0.00078658	dekaliters per second
179.53056	gallons per day
7.48050	gallons per hour
0.12467	gallons per minute
0.0020779	gallons per second
149.48928	gallons (Imperial) per day
6.22889	gallons (Imperial) per hour
0.10381	gallons (Imperial) per minute
0.0017302	gallons (Imperial) per second
718.13952	quarts per day
29.92257	quarts per hour
0.49871	quarts per minute
0.0083118	quarts per second
679.60512	liters per day
28.317	liters per hour
0.47195	liters per minute
0.0078658	liters per second
679.60512	cubic decimeters per day
28.317	cubic decimeters per hour
0.47195	cubic decimeters per minute
0.0078658	cubic decimeters per second
1,436.31360	pints per day
59.84515	pints per hour
0.99744	pints per minute
0.016624	pints per second
5,745.25440	gills per day
239.38060	gills per hour
3.98976	gills per minute
0.066496	gills per second
6,796.05120	deciliters per day
283.17	deciliters per hour
4.71948	deciliters per minute
0.078658	deciliters per second
41,472.0	cubic inches per day
1,727.98829	cubic inches per hour
28.80	cubic inches per minute
0.480	cubic inches per second
67,960.512	centiliters per day
2,831.7	centiliters per hour
47.19480	centiliters per minute
0.78658	centiliters per second
679,605.120	milliliters per day
28,317	milliliters per hour
471.94980	milliliters per minute
7.86583	milliliters per second
697,605.120	cubic centimeters per day
28,317	cubic centimeters per hour
471.94980	cubic centimeters per minute
7.86583	cubic centimeters per second
679,605,120	cubic millimeters per day
28,317,000	cubic millimeters per hour
471,949.80	cubic millimeters per minute
7,865.83	cubic millimeters per second

TONS (LONG) =

1	tons (long)
1.0160470	tons (metric)

Compiled by Steven Gerolde, Gulf Oil Corporation

Design for Longer Living



...You find it only in

CHAPMAN'S

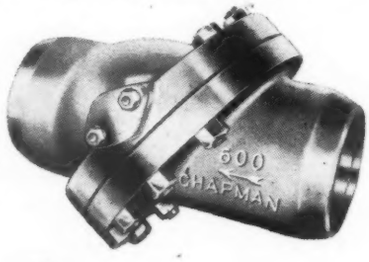
Tilting Disc CHECK VALVE

Here you can see the specially designed *airfoil section* of the disc in the Chapman Tilting Disc Check Valve . . . and you can see how the disc-seat lifts away from the body seat when opening (and drops into contact when closing) with no *sliding or wearing of the seats.*

Under usual piping arrangements this unique designed disc won't slam . . . just cushions itself to a quiet closing that does not even jar the line.

And this balancing is the reason why Chapman Tilting Disc Check Valves greatly reduce head-loss over standard designed swing-type checks . . . as proven by tests in leading engineering schools and by actual performance in the field.

Available in iron or steel. Complete test data is given in Catalog No. 30–write for your copy now.



The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS

OIL IN PLACE, BBL. PER ACRE FT.

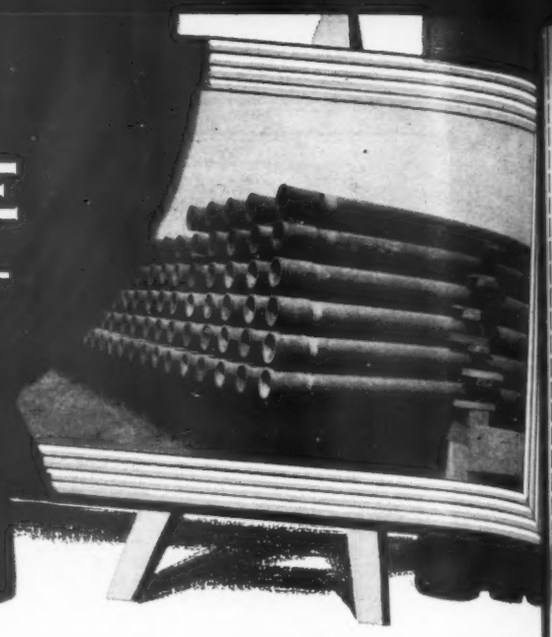
Saturation, percent	Porosity, percent																	
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
14	87	98	109	119	130	141	152	163	174	185	196	206	217	228	239	250	261	272
16	99	112	124	137	149	161	174	186	199	211	223	236	248	261	273	286	298	310
18	112	126	140	154	168	182	196	209	223	237	251	265	279	293	307	321	335	349
20	124	140	155	171	186	202	217	233	248	264	279	295	310	326	341	357	372	388
22	137	154	171	188	205	222	239	256	273	290	307	324	341	358	376	393	410	427
24	149	168	186	205	223	242	261	279	298	317	335	354	372	391	410	428	447	466
26	161	182	202	222	242	262	282	303	323	343	363	383	403	424	444	464	484	504
28	174	196	217	239	261	282	304	326	348	369	391	413	434	456	478	500	521	543
30	186	209	233	256	279	303	326	349	372	396	419	442	466	489	512	535	559	582
32	199	223	248	273	298	323	348	372	397	422	447	472	497	521	546	571	596	621
34	211	237	264	290	317	343	369	396	422	448	475	501	528	554	580	607	633	659
36	223	251	279	307	335	363	391	419	447	475	503	531	559	587	614	642	670	698
38	236	265	295	324	354	383	413	442	472	501	531	560	590	619	649	678	708	737
40	248	279	310	341	372	403	434	466	497	528	559	590	621	652	683	714	745	776
42	261	293	326	358	391	424	456	489	521	554	587	619	652	684	717	749	782	815
44	273	307	341	376	410	444	478	512	546	580	614	649	683	717	751	785	819	853
46	286	321	357	393	428	464	500	535	571	607	642	678	714	749	785	821	857	892
48	298	335	372	410	447	484	521	559	596	633	670	708	745	782	819	857	894	931
50	310	349	388	427	466	504	543	582	621	659	698	737	776	815	853	892	931	970
52	323	363	403	444	484	524	565	605	646	686	726	767	807	847	888	928	968	1009
54	335	377	419	461	503	545	587	628	670	712	754	796	838	880	922	964	1006	1047
56	348	391	434	478	521	565	608	652	695	739	782	826	869	912	956	999	1043	1086
58	360	405	450	495	540	585	630	675	720	765	810	855	900	945	990	1035	1080	1125
60	372	419	466	512	559	605	652	698	745	791	838	884	931	978	1024	1071	1117	1164
62	385	433	481	529	577	625	673	722	770	818	866	914	962	1010	1058	1106	1154	1203
64	397	447	497	546	596	646	695	745	794	844	894	943	993	1043	1092	1142	1192	1241
66	410	461	512	563	614	666	717	768	819	871	922	973	1024	1075	1127	1178	1229	1280
68	422	475	528	580	633	686	739	791	844	897	950	1002	1055	1108	1161	1213	1266	1319
70	434	489	543	597	652	706	760	815	869	923	978	1032	1086	1140	1195	1249	1303	1358
72	447	503	559	614	670	726	782	838	894	950	1006	1061	1117	1173	1229	1285	1341	1397
74	459	517	574	632	689	746	804	861	919	976	1033	1091	1148	1206	1263	1320	1378	1435
76	472	531	590	649	708	767	826	884	943	1002	1061	1120	1179	1238	1297	1356	1415	1474
78	484	545	605	666	726	787	847	908	968	1029	1089	1150	1210	1271	1331	1392	1452	1513
80	497	559	621	683	745	807	869	931	993	1055	1117	1179	1241	1303	1365	1428	1490	1552
82	509	573	636	700	763	827	891	954	1018	1082	1145	1209	1272	1336	1400	1463	1527	1590
84	521	587	652	717	782	847	912	978	1043	1108	1173	1238	1303	1369	1434	1499	1564	1629
86	534	601	667	734	801	867	934	1001	1068	1134	1201	1268	1334	1401	1468	1535	1601	1668
88	546	614	683	751	819	888	956	1024	1092	1161	1229	1297	1365	1434	1502	1570	1639	1707
90	559	628	698	768	838	908	978	1047	1117	1187	1257	1327	1397	1466	1536	1606	1676	1746
92	571	642	714	785	857	928	999	1071	1142	1213	1285	1356	1428	1499	1570	1642	1713	1784
94	583	656	729	802	875	948	1021	1094	1167	1240	1313	1386	1459	1532	1604	1677	1750	1823
96	596	670	745	819	894	968	1043	1117	1192	1266	1341	1415	1490	1564	1639	1713	1788	1862
98	608	684	760	836	912	988	1064	1140	1217	1293	1369	1445	1521	1597	1673	1749	1825	1901
100	621	698	776	853	931	1009	1086	1164	1241	1319	1397	1474	1552	1629	1707	1784	1862	1940

UNIVERSALLY RATED...

A MASTERPIECE

IN THE ART OF STEELMAKING—

NATIONAL SEAMLESS



DEEP well drilling demands the utmost in strength of tubular materials. They must be worked hard, deep—must resist fatigue, twisting action, collapse. And they must always be capable of meeting the higher stresses of tomorrow.

National Seamless Oil Country Tubular Products are acknowledged the world over as the most ideal material for deep well work, from the standpoint of both steel quality and method of manufacture—for, in effect, this very method of manufacture is in itself a severe test of the uniformity and strength of the steel.

Manufacturing a seamless tube by the piercing method is one of the most difficult forging operations in the steel industry. Only steel of the very best forging properties and of high uniformity can be used for the seamless process, since piercing the solid billet tends to search out any defects in the metal. Consequently, as the art of steelmaking has improved, so has the quality of the steel used for NATIONAL seamless. The result—a masterpiece of high strength, high collapse resistance, and maximum security—National Seamless Oil Country Tubular material.

Significant National Tube Developments in the Oil and Gas Industry:

NATIONAL DEOXIDIZED BESSEMER STEEL CASING AND TUBING
Especially well-suited for oil production because of its combination of high yield strength and good ductility.

NATIONAL WARM-WORKED CASING
An extremely high-strength casing possessing a uniformity of physical properties which gives it high collapse resistance and greatly increased joint strength.

NATIONAL DEEP-WELL CASING
A stronger casing than is provided under A.P.I. specifications, to meet constantly increasing depths. Because it is intended for severe service it is hydrostatically tested to 80% of minimum yield strength up to a maximum of 12,000 p.s.i.

NATIONAL (B) BUTTRESS-THREAD CASING

Developed to satisfy the need for a casing joint which will safely and economically support the weight of deep-well casing. The buttress-thread joint is comparable in strength to that of the body of the pipe.

For further information on National Tube developments in the oil industry, write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION
PITTSBURGH, PA.
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS TRADE MARK

USS NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL

XUM

CHART FOR ESTIMATION OF NATURAL GAS RESERVES

This chart is based on data contained in the article, "Effect of Reservoir Depth on Gas Reserves," by K. Marschall Fagin as published in the October, 1945, issue of *The Petroleum Engineer*, pages 256 to 260, clusive.

*This chart is applicable to an acre-ft. of gas sand that has 9801 cu. ft. of effective porosity and produces 0.6 gravity gas.

**Standard cu. ft. at 14.65 lb. per sq. in., abs., and 60°F., using a terminal well head pressure of 125 lb. per sq. in., ga.

***The depth scale is applicable only to initial gas field pressures that are "normal," that is equivalent to a hydrostatic head of 435 lbs. per 1000 ft. of depth.

EXAMPLE:

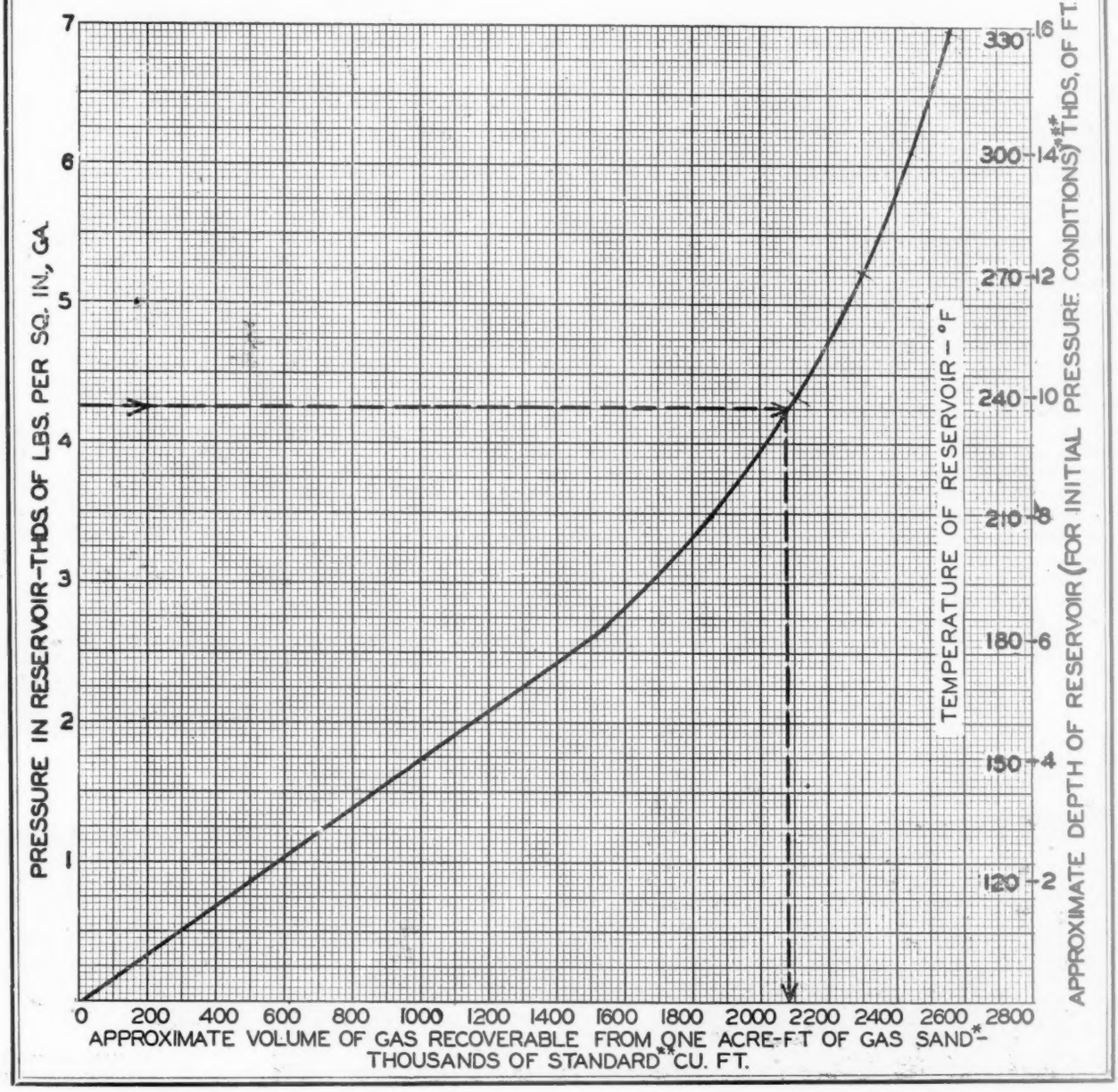
Given: A new gas reservoir with an initial pressure of 4250 lbs. per sq. in. ga., having sand with 9,801 cu. ft. of effective porosity per acre-ft.. reservoir temperature of 237°F., and producing 0.6 gravity natural gas.

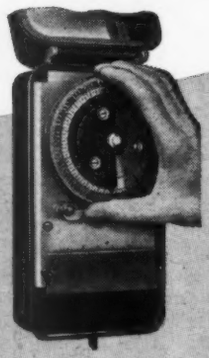
Required: An estimate of the ultimate recovery of gas per acre-ft.

Solution: Enter the chart from the 4250 lb. point on the pressure scale (as indicated) and proceed to the intersection with the curve. The answer, 2080 cu. ft. is found on the "recovery" scale directly below the intersection.

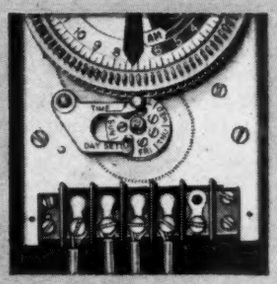
Note: The effective porosity of the gas sand = 43,560 cu. ft. × per cent porosity × (100 — per cent connate water).

If the effective porosity of the gas sand in question is more or less than 9,801 cu. ft., the recoverable volume of gas will be proportionately more or less.

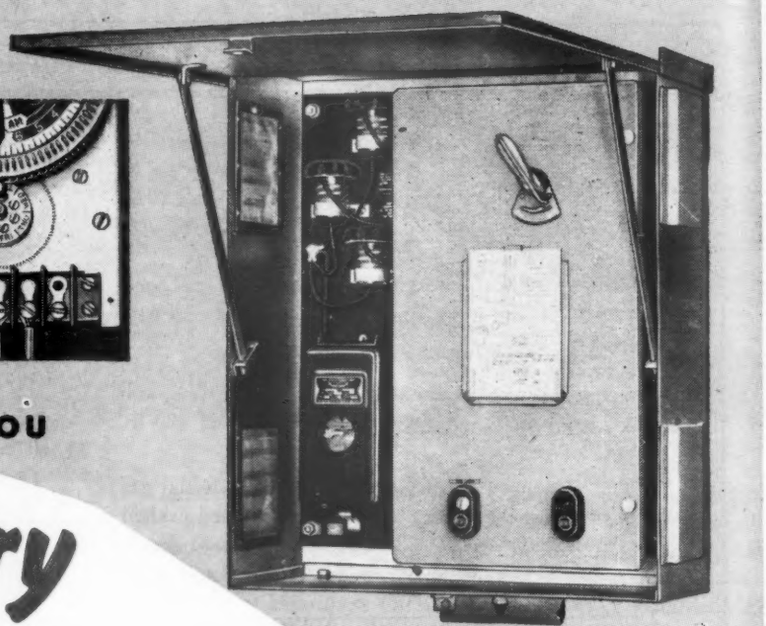




Cutler-Hammer Program Time Switch gives automatically scheduled pumping, set up easily by means of pull tabs—one for each 15 minute interval.



Day-omission feature—for non-operation any selected days of week.



Cutler-Hammer 9589 Oil Well Pumping Controller with 3 coil overload protection and time delay relay.

ONE TRIAL WILL TELL YOU
It's Genuine
Oil Country
Control

You'll only have to make a comparison *once* to see why Cutler-Hammer Oil Well Pumping Control is called *the* Oil Country Control and to see why oil men are installing it in preference to any others.

It is the outcome of a genuine, thorough and sincere contact with oil country conditions; with oil men's wishes. Not just to start, stop and protect motors and equipment successfully and dependably . . . but to meet and beat the oil country enemies of good performance . . . heat, humidity, static, dirt, dust, bugs, prevalent single phasing, sometimes careless handling.

Take a look at C-H. Note the ventilating openings that create a chimney draft to keep the "works" cool. Note the aluminum coating that bounces back the sun's rays. Note the out-in-the-open contacts that stay cooler and being "vertical," shed dust.

Note how all openings are screened, baffled, louvred to keep out dirt and dust, and bugs. See how Neoprene gasketing keeps dust out of the timer how the excess torque clock motor keeps "ticking" away even if dust gets in.

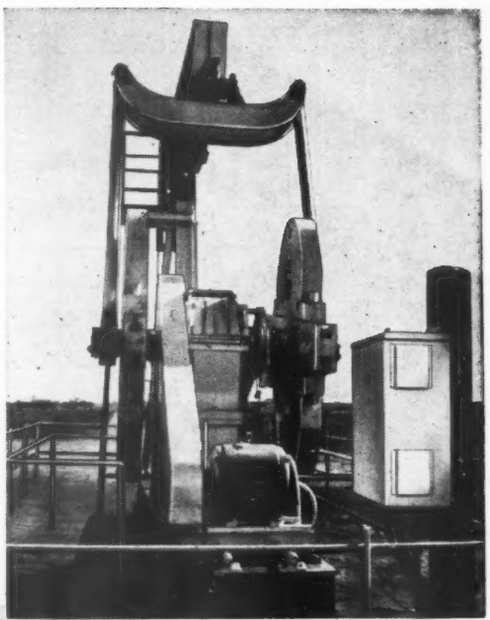
Take a look at the scheduling mechanisms, the easy on-off scheduling in 15 minute increments, the automatic day-omission feature. And there's manual or automatic restarting after an outage, either all at once or staggered starting.

Here's a popular feature too . . . optional 3 coil overload protection where single phasing is a problem; standard 2 coil where it is not a problem.

Note you don't have to rebuild or clean up the starter after a lightning arrester blows.

These are but some of the features that make this starter stand out like a derrick on a flat plain. Once you try it, you'll keep on using it.

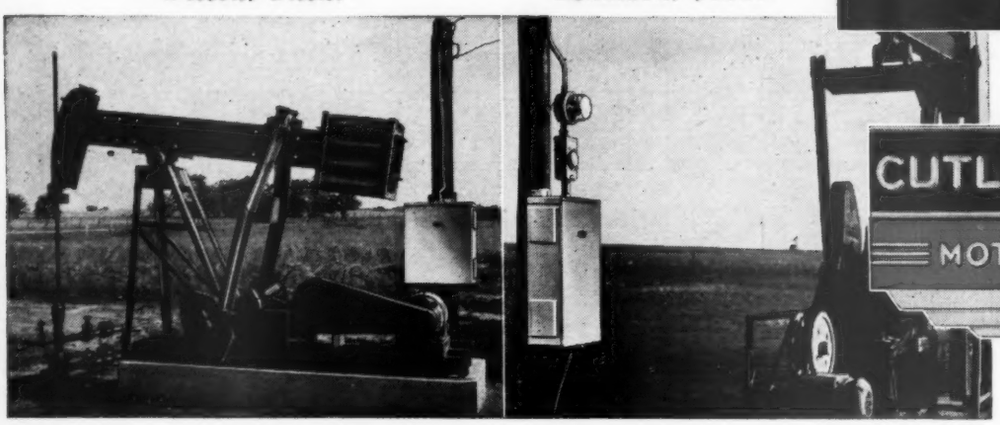
CUTLER-HAMMER, Inc., 1459 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



Snyder, Texas

Oilton, Okla.

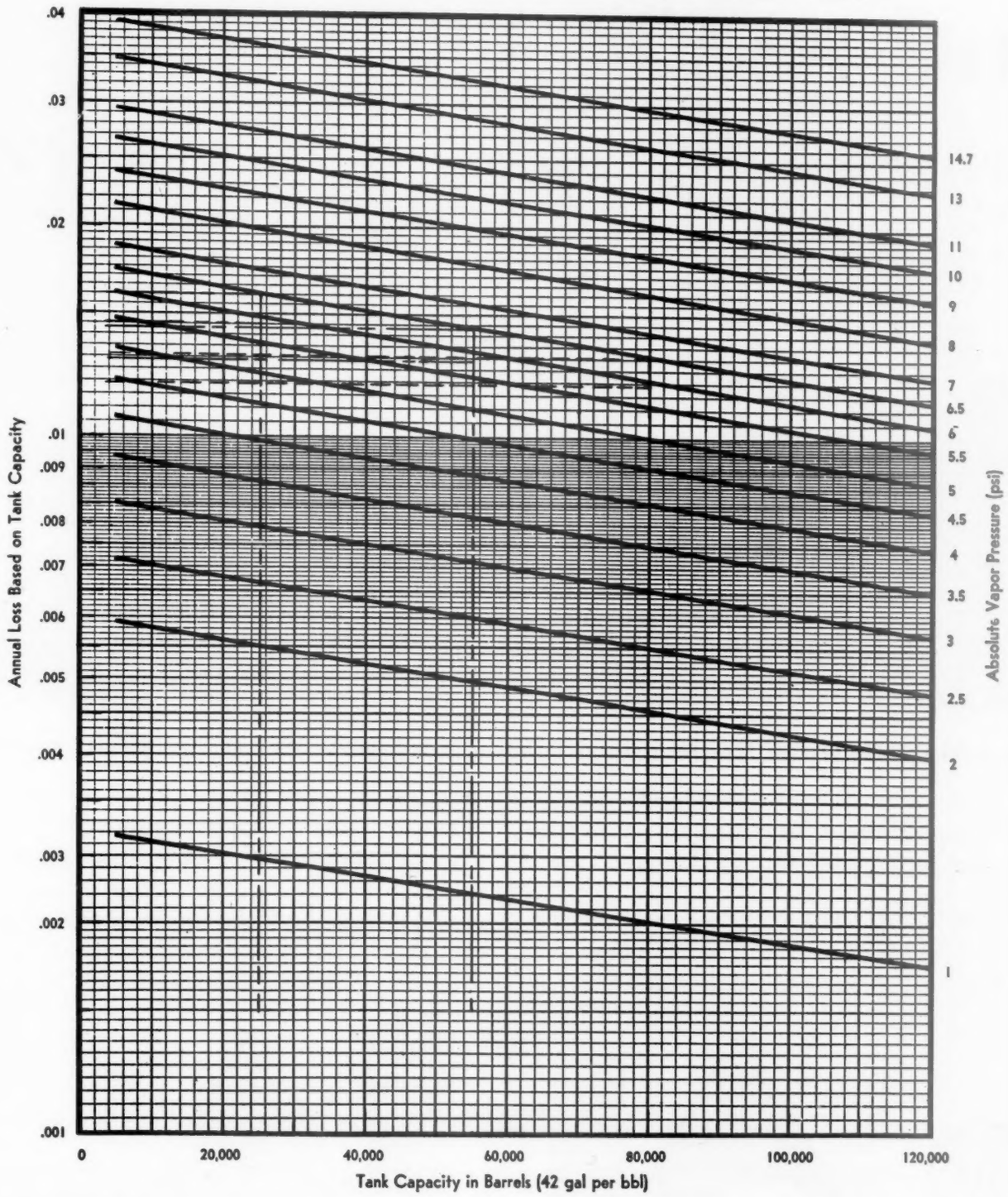
Lamesa, Texas



CUTLER-HAMMER
MOTOR CONTROL
C-H

MEMBER AMERICAN PETROLEUM INSTITUTE

AVERAGE STANDING LOSSES FROM FLOATING ROOF TANKS



EXAMPLE: A 9-pound Reid Gasoline stored at an average atmospheric temperature of 67.5 F. Liquid Surface Temperature = 77.5 F. Absolute Vapor Pressure = 6.5 psia.

Loss from 55,000 bbl tank = .0143 of capacity per year. Loss = .0143 x 55,000 = 787 bbl per yr.

LIMITATIONS: 1. Aluminum painted standard size tanks, half full.

2. Based on average of test data.

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XUM

Let's Face the Facts...

on safeguarding your company's investments in foreign lands

Despite most vigilant precautions, fires and accidents do happen the world over — and often with a serious jolt to financial security.

Then it is important that your insurance protection has been prepared by AFIA's experienced specialists in foreign insurance who have up-to-the-minute information continually flowing from 500 offices and agents throughout the world.

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SAN FRANCISCO OFFICE . . . . . 98 Post Street, San Francisco 4, California
WASHINGTON OFFICE . . Woodward Building, 733 15th Street, N.W., Washington 5, D.C.

SPHERE CAPACITY TABLE

Diam in Feet	VOLUME OF SPHERE			Surface in Sq Ft
	U. S. Barrels	U. S. Gallons	Cubic Feet	
1	0.09	3.89	0.52	3.14
2	0.75	31.34	4.19	12.57
3	5.04	105.77	14.14	28.27
4	8.95	250.67	33.51	50.27
5	11.66	489.60	65.45	78.54
6	20.	845.	113.1	113.1
7	32.	1,346.	179.6	153.9
8	48.	2,005.	268.1	201.1
9	68.	2,858.	381.7	254.5
10	93.	3,920.	523.6	314.2
11	124.	5,139.	696.9	380.1
12	161.	6,770.	904.8	452.4
13	205.	8,603.	1,150.3	530.9
14	256.	10,750.	1,436.8	615.8
15	315.	13,218.	1,767.1	706.9
16	382.	16,046.	2,145.	804.
17	458.	19,240.	2,572.	907.
18	544.	22,846.	3,054.	1,017.
19	640.	26,863.	3,591.	1,134.
20	746.	31,336.	4,189.	1,257.
21	864.	36,273.	4,849.	1,385.
22	993.	41,704.	5,575.	1,520.
23	1,135.	47,659.	6,371.	1,662.
24	1,289.	54,144.	7,238.	1,810.
25	1,457.	61,198.	8,181.	1,963.
26	1,639.	68,844.	9,203.	2,124.
27	1,836.	77,095.	10,306.	2,290.
28	2,047.	85,981.	11,494.	2,463.
29	2,275.	95,527.	12,770.	2,642.
30	2,518.	105,753.	14,137.	2,827.
31	2,778.	116,689.	15,599.	3,019.
32	3,056.	128,344.	17,157.	3,217.
33	3,352.	140,762.	18,817.	3,431.

Diam in Feet	VOLUME OF SPHERE			Surface in Sq Ft
	U. S. Barrels	U. S. Gallons	Cubic Feet	
34	3,666	153,950	20,580	3,632
35	3,998	167,931	22,449	3,848
36	4,351	182,742	24,429	4,072
37	4,724	198,399	26,522	4,301
38	5,117	214,924	28,731	4,536
39	5,532	232,338	31,059	4,778
40	5,969	250,673	33,510	5,027
41	6,428	269,951	36,087	5,281
42	6,911	290,260	38,792	5,542
43	7,415	311,416	41,630	5,809
44	7,944	333,647	44,602	6,082
45	8,498	356,919	47,713	6,362
46	9,077	381,246	50,965	6,648
46	9,682	406,628	54,362	6,940
48	10,313	433,137	57,906	7,238
49	10,972	460,809	61,601	7,543
50	11,657	489,602	65,450	7,854
51	12,371	519,569	69,456	8,171
52	13,113	550,733	73,622	8,495
53	13,884	583,124	77,952	8,825
54	14,685	616,756	82,448	9,161
55	15,515	651,661	87,144	9,503
56	16,376	687,808	91,953	9,832
57	17,270	723,213	96,967	10,207
58	18,194	764,164	102,161	10,568
59	19,152	804,369	107,536	10,936
60	20,142	845,973	113,098	11,310
61	21,166	888,976	118,847	11,690
62	22,244	933,415	124,788	12,076
63	23,338	979,314	130,924	12,469
64	24,469	1,027,709	137,528	12,868
65	25,607	1,075,512	143,793	13,273
66	26,809	1,125,987	150,533	13,685

Volume of Sphere $= \frac{\pi}{6} D^3 = 0.5236 D^3$ Cubic Feet
$= 0.0932 D^3$ U. S. Bbl

Surface of Sphere $= 3.1416 D^2$ Square Feet

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XUM

IT'S NICE TO DO BUSINESS WITH

FRIENDS!

Food is more nourishing when the environment is pleasant.

Medicine is more potent when you have confidence in your doctor.

These facts point up a subtle principle which affects commerce.

A wire rope, a string of pipe, a drilling rig or a pumping unit does a better job when friends supply it.

". . . here's MY warehouse!" is a phrase that friendship coined. It has a connotation we like and implies an obligation we respect.

J&L STEEL

Jones & Laughlin STEEL CORPORATION

SUPPLY DIVISION —— TULSA

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P·E·S·A PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION

PARTNERS IN PETROLEUM PROGRESS

UNIVERSAL CONVERSION FACTORS

BTU PER MINUTE (Continued)

0.0041997	kilogram calories per second
12,799.180803	ounce calories per day
533.299200	ounce calories per hour
8.88832	ounce calories per minute
0.148139	ounce calories per second
154,886.688000	kilogram meters per day
6,453.6120	kilogram meters per hour
107.56	kilogram meters per minute
1.79267	kilogram meters per second
14,980.0320	liter-atmospheres per day
624.168	liter-atmospheres per hour
10.40277	liter-atmospheres per minute
0.17338	liter-atmospheres per second
529.435728	cubic foot-atmospheres per day
22.059822	cubic foot-atmospheres per hour
0.3676637	cubic foot-atmospheres per minute
0.00612773	cubic foot-atmospheres per second
0.023252	cheval-vapeur hours
0.023575	horsepower
0.01757	kilowatts
17.57	watts
1,518,048	joules per day
63,252	joules per hour
1,054.198	joules per minute
17.569967	joules per second
0.098643	pounds of carbon oxidized with perfect efficiency per day
0.0041101	pounds of carbon oxidized with perfect efficiency per hour
0.0000685	pounds of carbon oxidized with perfect efficiency per minute
0.0000011417	pounds of carbon oxidized with perfect efficiency per second
1.48320	pounds of water evaporated from and at 212° F. per day
0.06180	pounds of water evaporated from and at 212° F. per hour
0.001030	pounds of water evaporated from and at 212° F. per minute
0.000017167	pounds of water evaporated from and at 212° F. per second
1,440	BTU per day
60	BTU per hour
1.0	BTU per minute
0.016667	BTU per second

BTU PER SECOND =

2,162,592,000	foot poundals per day
90,108,000	foot poundals per hour
1,501,800	foot poundals per minute
25,030	foot poundals per second
67,216,836.960	foot pounds per day
2,800,701.540	foot pounds per hour
46,678.3590	foot pounds per minute
777.97265	foot pounds per second
21,771.0720	kilogram calories per day
907.1280	kilogram calories per hour
15.1188	kilogram calories per minute
0.25198	kilogram calories per second
767,950.8480	ounce calories per day
31,997.9520	ounce calories per hour
533.29920	ounce calories per minute
8.88832	ounce calories per second
9,293,184.0	kilogram meters per day
387,216.0	kilogram meters per hour
6,453.60	kilogram meters per minute
107.56	kilogram meters per second
898,799.3280	liter-atmospheres per day
37,449.9720	liter-atmospheres per hour
624.16620	liter-atmospheres per minute
10.40277	liter-atmospheres per second
31,766.143680	cubic foot-atmospheres per day
1,323.589320	cubic foot-atmospheres per hour
22.0598220	cubic foot-atmospheres per minute
0.3676637	cubic foot-atmospheres per second
1.39519	cheval-vapeur
1.41454	horsepower
1.055	kilowatts
1,055	watts
91,082,707.2	joules per day
3,795,112.8	joules per hour
63,251.880	joules per minute
1,054.198	joules per second
5.9184	pounds of carbon oxidized with perfect efficiency per day
0.2466	pounds of carbon oxidized with perfect efficiency per hour
0.00411	pounds of carbon oxidized with perfect efficiency per minute
0.0000685	pounds of carbon oxidized with perfect efficiency per second
88.992000	pounds of water evaporated from and at 212° F. per day
3.70800	pounds of water evaporated from and at 212° F. per hour
0.061800	pounds of water evaporated from and at 212° F. per minute
0.001030	pounds of water evaporated from and at 212° F. per second
86,400	BTU per day
3,600	BTU per hour
60	BTU per minute
1	BTU per second

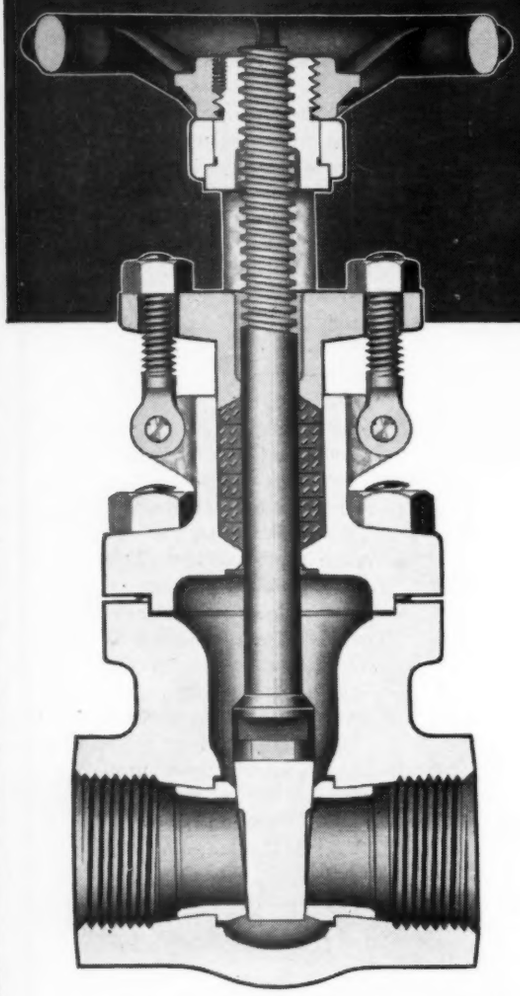
BTU PER SQUARE FOOT PER DAY =

23,505.12	kilowatts per square hektometer
235.0512	kilowatts per square dekameter
2.350512	kilowatts per square meter
25.30051	kilowatts per square foot
0.17569	kilowatts per square inch
0.023505	kilowatts per square decimeter
0.00023505	kilowatts per square centimeter
0.0000023505	kilowatts per square millimeter
23,505,120	watts per square hektometer
235,051.2	watts per square dekameter
2,350.512	watts per square meter
25,300.512	watts per square foot
175.6944	watts per square inch
23.50512	watts per square decimeter
0.23505	watts per square centimeter
0.0023502	watts per square millimeter
31,537.728	horsepower per square hektometer
315.37728	horsepower per square dekameter
3.15377	horsepower per square meter
33.94829	horsepower per square foot
0.23576	horsepower per square inch
0.031538	horsepower per square decimeter

Compiled by Steven Gerolde, Gulf Oil Corporation

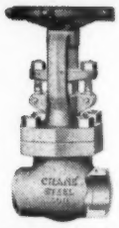
XUM

You get Big Valve quality in these SMALL 600-POUND STEEL GATES by CRANE

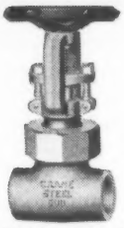


BOLTED BONNET OR UNION BONNET

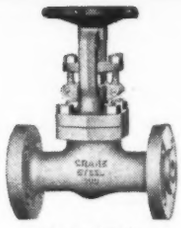
In the cross-section of the bolted bonnet pattern above, you can see the rugged *big-valve* construction. Bolted bonnet valves available in sizes ½ to 2-inch—union bonnet valves in sizes ¼ to 2-inch.



Screwed Ends—Union Bonnet or Bolted Bonnet



Socket-Welding Ends—Bolted Bonnet or Union Bonnet



Flanged Ends—Bolted Bonnet only

Look no further for dependable steel valves in sizes up to 2-inch. Whether you prefer the union bonnet or bolted bonnet pattern, you get refinements usually found only in larger, more expensive valves.

For example, you get a compact, weight-saving structure of high-quality carbon steel. Smooth operation and positive closure of the solid wedge disc are assured by a T-head disc-stem connection and full-length machined guide ribs. There's also an unusually large stuffing box filled with high-grade packing, a leakproof bonnet joint with retained gasket, a husky stem with outside threads, and many others. To simplify maintenance, Crane design includes swinging gland eye-bolts—plus a wide yoke with liberal working space around the gland.

USER'S CHOICE OF TRIM

There's versatility to these quality Crane steel valves, too. You can have your choice of trim to suit your service—Class X Trim (Exelloy body and body seat rings) for oil or oil vapor—Class XW Trim (Exelloy seat rings, disc of hardened stainless steel) for steam or water. Union bonnet valves also available with Class L Trim (18-8 Mo Alloy seats, disc, stem) for liquids and gases up to 750° F.

Full details in 6-page folder AD-1881. Ask your Crane Representative next time he calls, or write direct.

THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

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VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Dry-Bulb and Wet-Bulb Design Summer Temperatures for Various Applications in Typical U.S.A. Cities

State	City	Design Dry-bulb Temperature 60 hr. (2%)† deg. F	Design Wet-bulb Temperatures			
			Critical Full-load Requirements 60 hr. (2%) † deg. F.	ACRMA* Recommendations, Air Conditioning 150 hr. (5%)† deg. F	Steam Turbines, Diesel Engines; Full-load, Continuous. 600 hr. (20%) †	Steam Turbines, Diesel Engines; Partial-load, Intermittent. Refrigeration. 1000 hr. (35%) †
Massachusetts	Boston	90	75	75	68	65
	Fitchburg	92	75	75	68	65
	Springfield	92	75	75	68	65
	Worcester	92	75	75	68	65
Michigan	Detroit	93	75	75	69	66
	Flint	95	75	75	69	66
	Grand Rapids	95	76	75	69	66
	Saginaw	95	75	75	69	66
Minnesota	Duluth	93	74	73	67	65
	Minneapolis	95	76	75	68	66
	St. Paul	95	76	75	68	66
Mississippi	Vicksburg	98	80	78	77	75
Missouri	Kansas City	100	77	75	73	71
	St. Louis	100	77	76	73	71
Montana	Billings	92	66	66	58	55
	Helena	92	65	65	58	55
	Missoula	92	66	66	58	55
Nebraska	Lincoln	98	78	77	72	70
	Omaha	98	77	77	72	70
Nevada	Reno	96	65	65	58	55
New Hampshire	Concord	88	73	73	69	65
	Manchester	90	75	75	68	65
	Portsmouth	88	73	73	69	65
New Jersey	Camden	95	78	76	72	70
	Jersey City	92	77	75	71	69
	Newark	92	77	75	71	68
	Trenton	93	78	78	72	69
New Mexico	Albuquerque	96	70	68	66	64
	Santa Fe	95	65	65	58	55
New York	Albany	92	75	75	67	64
	Buffalo	92	75	75	70	68
	New York	93	77	75	71	69
	Rochester	92	75	75	70	68
	Syracuse	92	75	75	70	68
North Carolina	Asheville	90	75	75	68	65
	Charlotte	93	76	75	74	72
	Greensboro	93	76	75	74	72
	Raleigh	93	79	76	75	73
	Wilmington	93	80	78	77	75
North Dakota	Bismarck	95	73	73	68	65
Ohio	Akron	95	75	75	72	70
	Canton	95	75	75	70	67
	Cincinnati	96	78	78	73	70
	Cleveland	94	75	75	69	66
	Columbus	95	77	76	70	67
	Dayton	95	77	76	70	67
	Toledo	94	75	75	69	66
	Youngstown	95	75	75	70	67
Oklahoma	Oklahoma City	102	78	77	74	72
	Tulsa	102	78	77	74	72
Oregon	Baker	90	66	66	60	58
	Portland	90	68	68	62	59
	Roseburg	90	66	66	60	58

*"Application Engineering Standards for Air Conditioning for Comfort", Air Conditioning and Refrigerating Machinery Association, Inc., Washington, D. C.

†Temperatures listed will not be exceeded more than time indicated, June to Sept., incl.

NOTE: For installations in the center of large cities and in industrial areas, it is recommended that the design temperatures be about 2 degrees higher than the values listed.

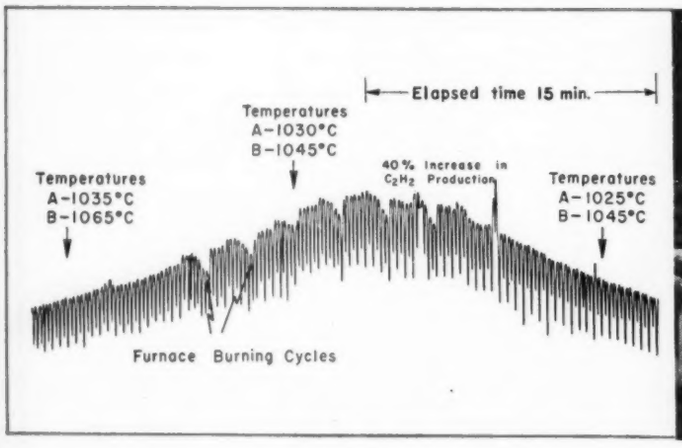
Courtesy of Marley Company

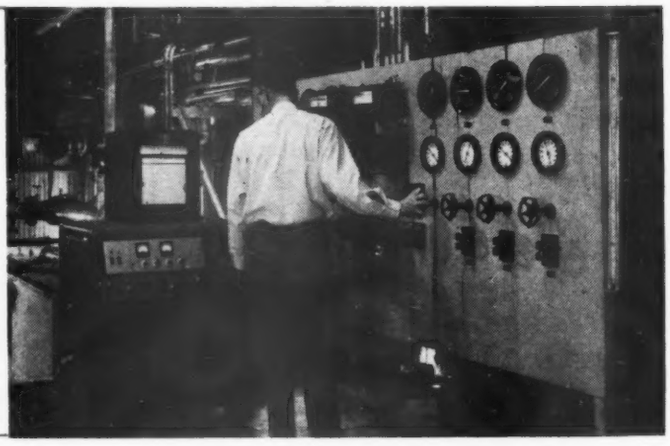
XUM

New acetylene production process uses the Consolidated continuous process–monitoring mass spectrometer..... for "on the spot" control

The new Consolidated Model 21-610 continuous process monitoring mass spectrometer played a part in the development of the Wulff Process for the commercial production of acetylene. Requiring only 110 volts and a small quantity of cooling water for operation, this self-contained, completely portable instrument was placed on stream in the pilot plant, where it monitored various gas streams under a variety of imposed conditions. Samples from 19 different points, introduced through a common manifold for analysis, made possible among other things: (1) the monitoring of feed stock, (2) evaluation of cracking gas composition versus temperature, (3) determination of fuel gas composition, (4) measurement of acetylene or ethylene content in recycle gas, (5) diacetylene scrubber efficiency, (6) acetylene or ethylene absorber efficiency, (7) solvent recovery and/or loss, (8) final product purity.

The chart, below, left, illustrates the versatility and practical value of the Model 21-610 as a production control instrument. The mass-26 peak of acetylene was monitored in the cracking gas coming directly from the unit as the furnace temperature was varied. From right to left, the temperature was slowly increased. The rise in the cyclically scanned 26 peak indicates rising acetylene content of feed stock. This test showed that acetylene increased approximately 40% with a temperature rise of 5 degrees C. Using the chart as a reference, guesswork was eliminated and maximum future production assured. Write for Bulletin CEC-1824-X21.





Consolidated Engineering CORPORATION

ANALYTICAL INSTRUMENTS FOR SCIENCE AND INDUSTRY

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service through **CEC INSTRUMENTS, INC.** *a subsidiary with offices in: Pasadena, Atlanta, Dallas, Detroit, New York, Philadelphia, Washington, D. C.*

Dry-Bulb and Wet-Bulb Design Summer Temperatures for Various Applications in Typical U.S.A. Cities

State	City	Design Dry-bulb Temperature 60 hr. (2%)† deg. F.	Design Wet-bulb Temperatures			
			Critical Full-load Requirements 60 hr. (2%) † deg. F.	ACRMA* Recommendations, Air Conditioning 150 hr. (5%)† deg. F.	Steam Turbines, Diesel Engines; Full-load, Continuous. 600 hr. (20%) †	Steam Turbines, Diesel Engines; Partial-load, Intermittent. Refrigeration. 1000 hr. (35 %)†
Pennsylvania	Altoona	90	75	75	70	67
	Erie	90	75	75	70	67
	Harrisburg	92	75	75	70	67
	Oil City	90	75	75	70	67
	Philadelphia	95	78	76	72	70
	Pittsburgh	95	75	75	70	67
	Scranton	90	75	75	70	67
Rhode Island	Pawtucket	90	75	75	70	68
	Providence	90	75	75	70	68
South Carolina	Charleston	93	80	78	77	75
	Columbia	93	76	75	74	73
	Greenville	93	75	75	74	73
South Dakota	Sioux Falls	98	75	75	68	64
Tennessee	Chattanooga	95	77	76	73	71
	Knoxville	93	77	76	73	71
	Memphis	98	80	78	76	74
	Nashville	95	79	76	74	72
Texas	Abilene	100	75	75	73	72
	Austin	98	79	78	75	74
	Corpus Christi	95	80	80	78	76
	Dallas	100	78	78	75	74
	El Paso	98	70	69	67	65
	Fort Worth	100	78	78	75	74
	Galveston	95	80	80	78	77
	Houston	95	80	78	77	76
	Lubbock	100	72	72	70	70
	San Antonio	98	79	78	75	74
	Port Arthur	95	80	80	78	77
	San Angelo	100	74	74	72	71
	Wichita Falls	100	76	76	74	73
Utah	Salt Lake City	97	66	65	59	57
Vermont	Burlington	88	73	73	69	65
	Rutland	88	73	73	69	65
Virginia	Norfolk	95	78	78	75	74
	Richmond	95	78	78	75	74
	Roanoke	95	76	76	72	70
Washington	Seattle	85	67	65	61	59
	Spokane	92	65	65	59	55
	Tacoma	85	66	64	60	58
	Walla Walla	90	66	65	62	60
	Wenatchee	90	66	65	62	60
	Yakima	90	66	65	62	60
West Virginia	Bluefield	95	75	75	70	68
	Charleston	95	75	75	70	68
	Huntington	95	77	76	72	70
	Parkersburg	95	76	75	70	68
	Wheeling	95	75	75	70	68
Wisconsin	Madison	95	75	75	70	67
	Milwaukee	95	75	75	70	67
Wyoming	Cheyenne	95	65	65	56	53

*"Application Engineering Standards for Air Conditioning for Comfort", Air Conditioning and Refrigerating Machinery Association, Inc., Washington, D. C.

†Temperatures listed will not be exceeded more than time indicated, June to Sept., incl.

NOTE: For installations in the center of large cities and in industrial areas, it is recommended that the design temperatures be about 2 degrees higher than the values listed.

Courtesy of Marley Company

XUM

LAUGH with BARNEY

An old maid went to a pet shop to purchase a parrot. She wanted a very nice one though. He could talk but he must talk nice. The pet shop owner looked around and said, "I have just the bird you want. This parrot here, as you can see, has a string tied to each leg. Pull the string on his right leg and he recites the Ten Commandments. Pull the string on his left leg and he recites the Lord's Prayer."

The old maid considered for a moment and said, "What happens if I pull both strongs?"

"I'd fall on my pratt, you darn fool!" yelled the parrot.

* * *

"Why are you scratching your head, Rastus?"

"Aw, suh, I got arithmetic bugs in my head, suh."

"What are arithmetic bugs?"

"Dat's cooties."

"What do *they* have to do with arithmetic?"

"Well, suh, dey add to my misery, subtract from my pleasuah, divide my attention, and multiply like everything!"

* * *

An eager sportsman accosted one of the natives in the small town where he was spending his vacation. "Is there good hunting here?" he asked eagerly.

The native glanced around him for a minute and then answered, "Sure, there's plenty of huntin', but darned little findin'."

A man took his grandfather to see his first ballgame and lost him in the large crowd. After much frantic searching, he found him and said, let's sit down," its the end of the fifth."

"That's all right," he replied. "I brought my own bottle."

* * *

A few years ago, the police department in our town was swamped with calls from women who reported being frightened by a man, wearing absolutely nothing, who would jump out of alleys and dark doorways and yell at them. He never made any attempt to molest his victims and, after screaming at them, would run back in and disappear before the police could get there.

For several months the reports came in practically every night, but at last the culprit was caught. The police department asked several of the women to identify him, but one of the ladies protested, I'm very sorry, "I'm not going to look at him nude again—and I didn't see his face before."

* * *

He was speaking to his four-year-old daughter.

"Have you a kiss for Daddy?"

"No."

"Shame on you. Your Daddy works hard all day to bring home a little money and you behave like that. Come on now, where's the kiss?"

Looking him right in the eye, the sagacious tot countered, "Where's the money?"

The nurse complained that her young college student patient was complaining about not getting enough attention.

"Well give him what he wants," the doctor advised.

"I'll quit this job first," she snapped.

* * *

Walking down an old country road, farmer suddenly came upon an elephant sitting in the middle of the road. Scarcely believing his eyes, he pinched himself and continued walking along the road, mumbling something about laying off the liquor. Having walked some hundred yards or so, he stopped in amazement, for there in the middle of the road was another elephant, sitting with his back to the first elephant. This was too much.

"I beg your pardon," he said to this second elephant, "but what are you and your friend up the road doing just sitting out here?"

The elephant smiled, "We're playing bookends."

* * *

Sue, a four year old, was told by her father that if she'd be good he would bring home a little baby, so when twins arrived she asked, "Daddy, was I too good?"

* * *

At a southwestern university not long ago, a girl walked into her freshman dormitory beaming happily as she announced that Charley, the fellow she'd been dating, had given her his fraternity pin that evening.

"Pinned!" cried one. "Let's see it!" The newly-pinned freshman became completely distressed when she looked down at the front of her sweater to find that Charley's pledge of devotion had apparently become unfastened and dropped off. Suddenly, a girl standing nearby whose face had become unusually red exclaimed, pointing, "There's the pin—right there!"

Charley's girl had come in from their date with her sweater on backwards.

* * *

Mother (examining toy): Isn't this rather complicated for a small child?

Clerk: It's an educational toy, Madam, designed to adjust a child to live in the world today. Anyway he puts it together, it's wrong.

* * *

A mother took her young son to the store to buy a sweater. The only style in stock was the V-neck sweater. As each sweater was shown to the boy he shook his head and said, "No, I don't want that kind."

Finally, the mother in desperation, asked the boy why he didn't want a V-neck sweater.

His reply was quick and to the point: "My teacher wears that kind and every time she bends over you can see her lungs!"

He went home without a sweater.

* * *

When the husband came home drunk his wife assailed him with, "If you don't stop this drinking and carousing, I'm going to kill myself!"

Retorted the hapless husband, "Promises! That's all I get . . . just promises!"

* * *

"How'd you get that black eye?"

"From a cough."

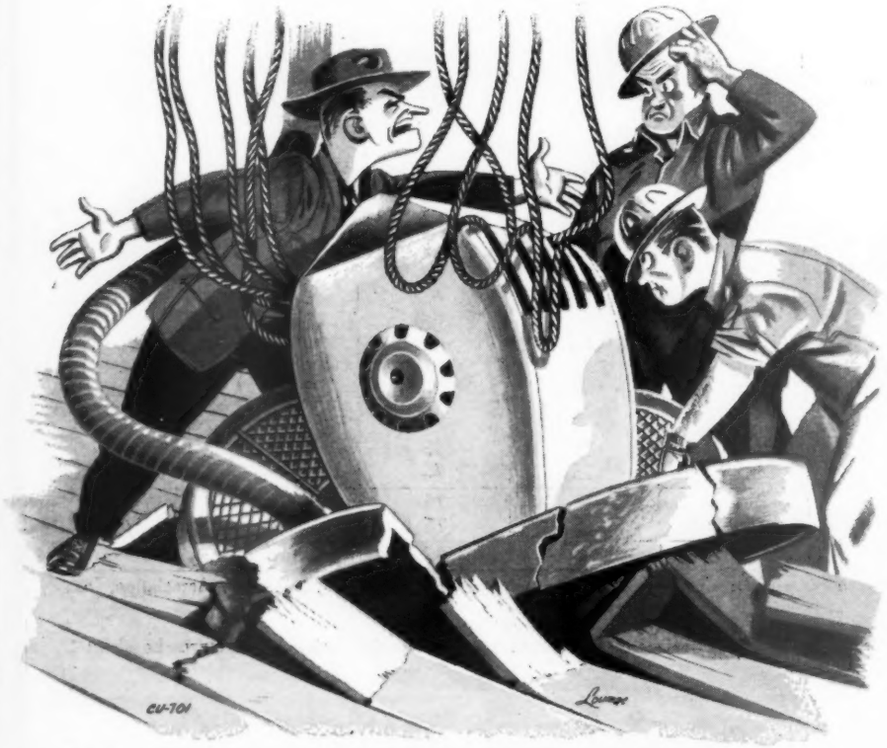
"From a cough?"

"Yeah, I coughed in a clothes closet."

* * *

Lawyer: "You say you want to get a divorce on the grounds that your husband is careless about his appearance?"

Client: "Yes, he hasn't shown up in nearly two years."



"SO YOU DIDN'T BELIEVE ME WHEN I SAID THAT A LANE-WELLS BRIDGING PLUG DRILLS OUT **FAST**!

OIL and GAS TRADE NEWS

New Area Representative

Allan Edwards Company, Inc., has been appointed Mid-Continent area representative for Warner-Lewis Company. Territory covers Oklahoma, Kansas, Nebraska, and Arkansas. In addition to the home offices, in Tulsa, Allan Edwards maintains branch offices in Dallas, Texas, and Kansas City.

Hawthorne Appoints Dealers

Herb J. Hawthorne, Inc., Houston, Texas, manufacturers of "Blue Demon" exploration drill bits, has announced two new dealers. They are Colorado Pump and Supply Company of Denver, Colorado, and A-D Machinery of Elko, Nevada.

New Branches Opened

Lane-Wells Company has opened three new branches bringing the total to 95 in the United States, Venezuela, and Canada. New truck stations were opened at Pleasanton and Seminole, Texas. R. H. Ault is operator in charge of the new Pleasanton base on Floresville Highway. The Gulf Coast division sales department is in Bankers Mortgage Building. R. E. Parmley is superintendent of Seminole base.

Ad Series Awarded

A series of three-color, two-page spread advertisements for Mission Manufacturing Company, run in The Petroleum Engineer in 1953 has been given an Award of Merit by Associated Business Publications.

Series was prepared by Rives, Dyke, Company, advertising agency, and is the only oil industry ads to receive recognition in this year's contests.

Beaird Group Meets

Sales representatives and engineers from the 48 state sales area of the J. B. Beaird Company, Inc., gathered in Shreveport, Louisiana, for the firm's annual spring sales meeting. Sixty men, including about 36 out of state representatives, participated in the educational and sales training program. The annual event is a phase of the continuous sales training program conducted by Beaird. Sales representatives present included those from the firm's subsidiary in Stockton, California.

Web Wilson to Sell and Manufacture "Deco" Slips

Manufacture and sale of the power slip previously made by the DeLaney Company, of Houston, Texas, has been purchased by Web Wilson Oil Tools, Inc. This product will be sold under the name "Web Wilson balanced power slip." Field warehouse stocks of all replacement parts will be carried for the owners of this power slip, and parts to be manufactured will be interchangeable with parts now in use.

ACF Purchases W-K-M

American Car and Foundry Company purchased the W-K-M Company of Houston, Texas. W-K-M, manufacturers of high pressure steel valves for oil field and pipeline equipment, will operate as a wholly owned subsidiary of ACF.

Otis Forms Agreement

Otis Pressure Control, Inc., has authorized the D&B Division of Emsco Manufacturing Company to sell and service the Otis Two-Zone pump. Engineering and manufacturing operations will be performed at the D&B plant in Garland, Texas.

Bantam No. "5000" Sold

The 5000th Bantam, a new crane carrier mounted crane dragline back hoe combination, developed by Schield Bantam Company, was delivered in March to Peter Kiewit Sons' Company of Denver, Colorado.

Vern L. Schield, president, G. O. Britton, general sales manager, made presentation to representatives of Peter Kiewit Sons.

Rust-Oleum Enlarges Plant

Rust-Oleum Corporation has opened new and enlarged plant facilities in Evanston, Illinois. This is the fourth new addition to the company's continuing program of plant expansion and incorporation of the most modern manufacturing processes.

New Ship in Service

The Marine Dow-Chem, new leased tanker of The Dow Chemical Company, is enroute to the eastern seaboard with a cargo of chemicals produced at the comcompany's Texas division at Freeport.

The 551-ft vessel, with a capacity of 3,500,000 gal, was equipped especially to carry liquid chemicals.

New Stores Open in Venezuela

Two new supply stores have been established in Venezuela by The Continental Supply Company. They are located at Anaco, and near the city of Las Morochas. Both stores will operate under the direction of H. E. Lowrey, manager of Venezuelan operations.

Manager of Anaco store is J. B. Hutchings, with F. W. Dawson as sales representative. Store manager at Maracaibo is J. A. Buehrer and sales representatives are J. B. McDonough and T. A. Mann.

Oilwell Unit Being Built

U. S. Steel Corporation's Oil Well Supply Division has begun construction of a new supply house at Houma, Louisiana. Melvin F. Jones, manager of "Oilwell's" Gulf Coast area, states unit will be the most modern of its type in the division and a key facility in supply and service activities in Louisiana.

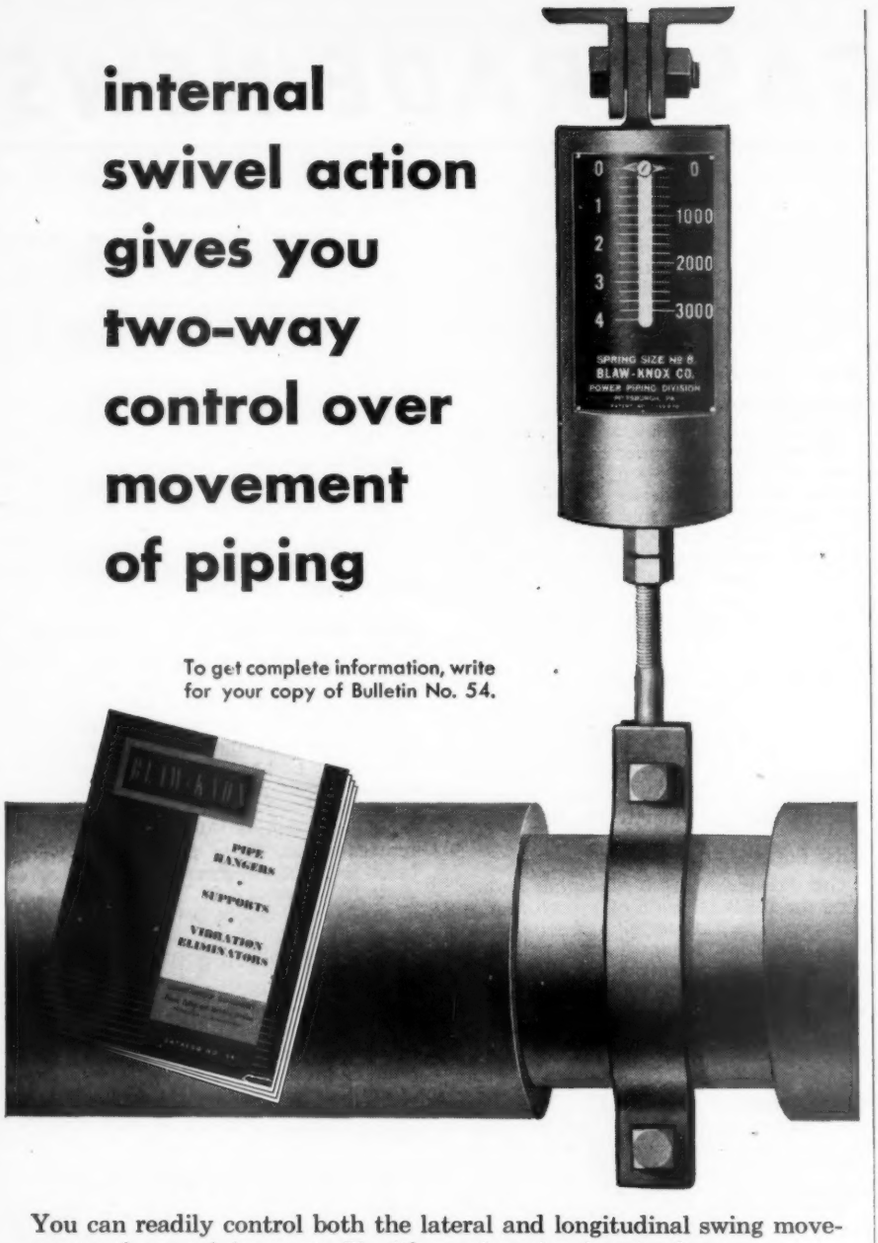
Cooper-Bessemer Office Opens

Opening of a branch office in Minneapolis, Minnesota, has been announced by The Cooper-Bessemer Corporation. R. B. Scott will be in charge of the branch.

Attending J. B. Beaird Company sales meeting were: First row, seated, H. H. Cochran, J. W. Hendryx, Horace Thomasson, S. L. Gordon, Al Berg, John Birkos. Second row, seated, W. W. Sentell, E. G. Owens, B. N. Owens, L. W. Abbott, Harold Graviss, Dawson Lary, George Crozier, Vernon Burkhead, Roy Hathorn. Standing, J. L. Tullis, Fred Hendrix, Gerald Pope, J. F. Atkinson, W. F. Raynolds, Raymond Keller, Leo Johnson, Ty Adams, J. L. Riseden, George Gaston, Bill Gulledge, C. Ray Elrod, E. S. McRoberts, Warren Parish, Richard Meisenbach, Charles Haynes, George Borgeson, V. L. Stevens, Paul Akers, Harry Gill, M. A. Finuf, Doug Winn, W. W. Marston, M. C. Phillips, R. W. Rademacher, Ken Miller, Rex Wheeler, Lee Rasmussen, and Jim Rigsby.

XUM

internal swivel action gives you two-way control over movement of piping



To get complete information, write for your copy of Bulletin No. 54.

You can readily control both the lateral and longitudinal swing movements of your piping up to 7° with our functional spring hanger.

For the hanger is designed with the Blaw-Knox patented *internal swivel action*, which permits movement while the hanger case itself remains vertical. Larger movements are readily accommodated by overhead roller assemblies. Each is a complete packaged unit ready to install.

In fact, our entire line of rigid hanger assemblies, overhead roller assemblies, vibration eliminators, as well as the functional hangers, are furnished as complete units . . . thereby saving you engineering time and eliminating expensive cutting, threading and assembling in the field.

Our engineers, who have had years of experience, are available to both design and make recommendations for your hanger requirements.

BLAW-KNOX COMPANY, Power Piping and Sprinkler Division, Pittsburgh 33, Pa.

BLAW-KNOX **PIPE HANGERS**

Complete line of functional spring hangers • rigid hanger assemblies • overhead roller assemblies • supports • vibration eliminators . . . plus complete prefabricated power piping systems for all pressures and temperatures.

Trade News

Continental Opens Store

In an expansion of its Canadian operations, The Continental Supply Company, Ltd., has announced the opening of a new store in Regina, Province of Saskatchewan. J. M. McNeill is manager of the Regina store and is assisted by J. B. Eyndhoven. Store is operating under the supervision of E. M. Fetzer, managing director of Canadian operations.

Trust Foundation Created

Through a donation from Wyatt Metal and Boiler Works the W. J. Wyatt Foundation has been created for public charittable purposes. Trustees are Mrs. Annie Belle Leavell, daughter of the late W. J. Wyatt; Raleigh Hortenstine, president of the corporation; George E. Gude, Jr., Walter B. Van Wart, vice presidents; and Guy Gambrell, secretary.

New Division Formed

Fairbanks, Morse and Company has announced the organization of a new electronics division. L. J. Maguire has been appointed manager of this new division.

This division will be responsible for research, development, application engineering, and manufacture of electronic devices and apparatus used in conjunction with various Fairbanks-Morse products.

New Firm Chartered

Relco Services, Inc., a new firm, has opened in Oklahoma City. Graham V. Taggart will be vice president and general manager. Relco services will include rights-of-way procurement, land acquisition and services involved in transcontinental pipe lines, engineering, etc.

Richardson Opens Offices

The Houston offices of Richardson X-Ray Service Corporation has been moved to Shreveport, Louisiana. H. E. Smith will be superintendent of the new office. A new office has also been opened in Missoula, Montana, under the direction of Andrew Vincent.

Dealer Appointed by Clark

Erie Industrial Trucks, Inc., has been granted a franchise for the sale and service of Clark industrial fork-lift trucks, according to W. E. Schirmer, vice president Clark Equipment Company. Russell McIlwain, as vice president and sales manager, and John J. Ucker, as secretary treasurer and general manager, will head the new dealer organization. Victor G. Didelot is sales engineer, and Dennis Galloway is service manager.

New Tax Plan Urged

Tax reform which spurs the incentives to greater industrial development will lighten the load for everybody, Crawford H. Greenewalt, Du Pont Company president, said in an address before the annual members luncheon meeting of the Economic Club of Detroit.

Our industrial economy is "directly or indirectly, the source of most of our tax revenues," he pointed out, "but the present tax system raises barriers to business expansion and improvement that would otherwise lower the burden for all."

"We should aim for a system based on low rates assessed, against a large and growing national output," Greenewalt emphasized. "The more we can increase our real wealth and income, the greater will be the gross tax yield."

AFIA Moves Offices

The Valparaiso branch office, under supervision of Victor Padilla, moved recently to a new office building in the center of the commercial bank district of Valparaiso, Chile. Another change to a larger office took place in Wellington, New Zealand. Office is under the supervision of R. L. Mark, manager for New Zealand. AFIA has also opened a new office in Zama, Japan. Enver Apanay will be manager of the new office.

AFIA recently began its new one-year training program of courses in accounting, foreign exchange, marine, fire, and casualty insurance.

Kaiser Group to Build Dam

The Kaiser-Walsh-Perini-Raymond group of American contractors has been awarded almost $60,000,000 for construction of a dam and a mammoth 14 mile water tunnel through the Snowy Mountains of Southeast Australia. The Snowy Mountain project is a plan to impound waters of the Snowy River and main tributaries and divert them through long tunnels to produce hydro-electric power for the Commonwealth.

Sales Department Expanded

The sales promotion department of D. W. Onan & Sons, Inc., has been expanded to include the advertising responsibilities of that firm. George Burda will direct the combined department. Julius P. Grabow will be assistant sales promotion manager, Russell V. Petersen, manager of literature production, and Virgil C. Gilbertson, manager of product publicity.

Security Expands Facilities

Security Engineering Division, Dresser Operations, Inc., has announced expansion of sales and service facilities in its Rocky Mountain division and Duncan, Oklahoma, district offices. Roland O. Crawford is the Rocky Mountain division manager, Bud Penniston, Rex Durham, R. S. Johnson, and Joe Abrams handle sales and service. The Duncan office is under the supervision of Floyd Huston. Gene Martin and Gilbert Charleston are the sales engineers for this area.

Carter Appoints Dealer

S. C. Carter Company, Inc., Los Angeles, has announced that Wilson Supply Company, has been appointed exclusive distributors for New Mexico and all of Texas except the Panhandle. Sales and service of Carter units will be handled under Ralph Crenshaw. Jack Baker will be Wilson's field representative for West Texas.

Office Opened by Dravo

A new southwest office at Houston has been opened by the machinery division of the Dravo Corporation. The Houston office will handle the sale of prefabricated steel and alloy piping for power plants, oil and gas transmission systems, refineries, petrochemical and chemical plants, and other manufacturing processes. George R. Beidler has been appointed district sales manager.

Ampco Appoints Distributor

The Aweco Supply Company, Tucson, Arizona, has been appointed distributor for the full line of Ampco Weldrod Products. The appointment is on an exclusive basis in the Tucson sales area, comprising the southern counties of Arizona.

Rodney S. Durkee

John H. Buck

Well Surveys Plans Expansion

Plans for expansion of Well Surveys, Inc., of Tulsa, Oklahoma, were revealed by Lane-Wells Company with purchase of the remaining 50 per cent of Well Surveys, Inc., capital stock from Socony-Vacuum Oil Company. Rodney S. Durkee, Lane-Wells president, has been elected president of Well Surveys. Dr. John H. Buck has been named vice president and technical director. D. W. Loots and Robert K. Schumacher have been named assistant treasurer and assistant secretary respectively.

Other officers are Russell M. Otis, and Morton T. Higgs, vice presidents, D. S. Jeppson, vice president and treasurer, and W. A. Miller, secretary and assistant treasurer.

G. E. Annual Meet Held

A total of 2454 share owners convened at Schenectady, New York, recently for the 62nd annual meeting of General Electric Company and heard president Ralph J. Cordiner announce:

1. G-E will spend a record total of $175,000,000 this year for new and modernized plants and equipment. This represents an increase of 24 per cent from last year.
2. Sales during the first quarter of 1954 reached $715,596,000 — a decline of eight per cent from last year.

Taylor Holds Seminar

The seminar on "Frequency Response" under the direction of William Caldwell and George Howard brought to Rochester 35 men from major process plants in this country and Canada. Subject matter for study included: "The Analysis of Time Lags by Step Response and Frequency Response"; "The Method of Obtaining Open Loop Data While the Process is Under Control." Taylor engineers also discussed "Dynamic Response of a Flow Process"; "Recovery Curves for Process Disturbances" and "Thermal Sine Wave Generators."

McCarty Opens Offices In New York and Dallas

The McCarty Company, advertising agency, has established offices in New York and Dallas by mergers with existing organizations. In New York, Laughlin-Wilson-Baxter & Persons, Inc., will operate as The McCarty Company Advertising Inc., of New York. In Dallas, the Russ Jurgens Advertising Agency will operate as The McCarty Company of Texas, Inc. Russ Jurgens will head the new operation as vice president and general manager.

Lima Announces Distributor

Baldwin-Lima-Hamilton Corporation, construction equipment division, Lima, Ohio, announces the appointment of Bradley Equipment Company, Atlanta, Georgia, as distributor for LIMA shovels, cranes, draglines and pull shovels. Distributorship covers the central and northeastern portions of Georgia.

DARCOVA

the original composition valve cup

famous for well pumping efficiency

...and low cost, too!

1. BEST QUALITY! The highest standards of quality and performance—backed by 50 years of experience—go into the manufacture of every *Darcova* valve cup, seating cup and ring.

2. PERFECT FIT! Consistent uniformity and precision manufacture to fit every size and make pump, assure *Darcovas* to be tops in efficiency of operation.

3. RIGHT TEXTURE! Varying conditions of depth, pressure, temperature, fluids and abrasion are not problems when *Darcovas* are used!

Best quality, perfect fit and right composition texture add up to longer, more efficient service...and LOWEST COST!

Be sure to specify DARCOVA at your supply store

DARLING VALVE & MANUFACTURING COMPANY

DARCOVA ®

THE ORIGINAL COMPOSITION CUP

WILLIAMSPORT 2, PA.

TRADE PERSONALS

C. T. Beaird

J. L. Tullis

M. F. Johnson

A. W. McKinney

Charles T. Beaird has been promoted to vice president of the J. B. Beaird Company, Inc., of Shreveport, Louisiana. He is also president and general manager of the Beaird Company of California, a subsidiary.

John L. Tullis was named vice president and general manager of sales. Tullis, who joined Beaird in 1947, is also vice president in charge of sales for the Beaird Company of California.

Melvin F. Johnson, Shreveport attorney, succeeds Charles T. Beaird as secretary. Re-elected were other officers and directors.

William L. Horner has been named as manager of reservoir engineering operations and a vice president of Core Laboratories, Inc. Horner will head Core Lab's expanded activities in similar services, including the management of producing properties. Since 1943 Horner has been with Sunray Oil and Barnsdall Oil Company.

William B. Tanner is new director of advertising for Frontier Industries, Inc. He was formerly director of advertising of The Aerovox Corporation and its subsidiaries.

G. D. McEnroe has been named as treasurer of Halliburton Oil Well Cementing Company. The new treasurer fills the vacancy created by the death of Hugh W. Leonard. McEnroe joined Halliburton in 1940 as a tax accountant at Halliburton's Duncan, Oklahoma, headquarters. He then filled the posts of chief tax accountant and assistant treasurer.

Arthur W. McKinney has been elected president of The National Supply Company. McKinney joined the company in 1920, and has served as executive vice president since 1948. He succeeds **Alexander E. Walker,** who was re-elected chairman of the board and chief executive officer of the company. McKinney is a graduate of Allegheny College.

Cecil W. Hays has been appointed sales representative for The Wheland Company in the Texas Gulf Coast area. He was formerly with Lee C. Moore Corporation.

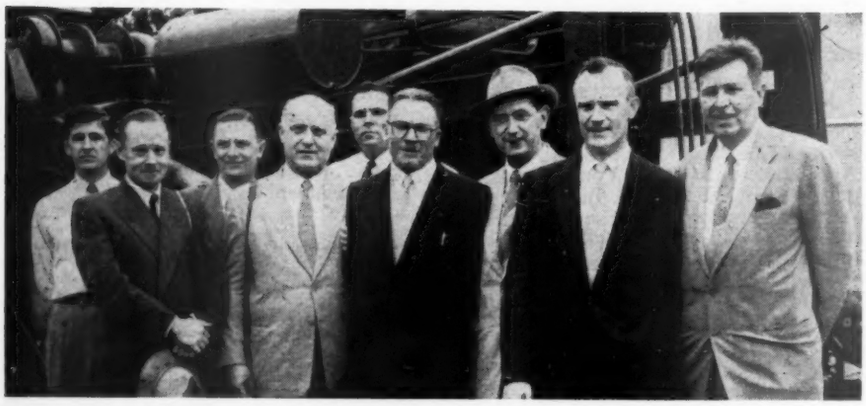
James McFadden

John Brennan

James M. McFadden has joined Fluid Packed Pump Company as controller. A graduate of the University of California, he was formerly with Axelson.

John R. Brennan has been promoted to chief engineer. Brennan, who was formerly with The Union Oil Company is a graduate of Oregon State College.

J. B. Stumm has announced his resignation from Byron Jackson Company. He was assistant to the general sales manager and also directed advertising and sales promotion for the company.



Five German pipe line engineers and industrialists, who are touring the U.S.A. were flown to Houston recently by Crutcher-Rolfs-Cummings to see C-R-C's permanent automatic pipe yard. Pictured: Jack Scott of C-R-C, Siegfried Schwaigerer, Werner Versen, Wilhelm Jamm, A. E. Johnson of C-R-C, Wihelm Raedeker, Hans Geilenkeuser, Bob Hoslander of Rhinetubes, Inc., Houston, and J. S. Ahearn of Sipanam, Inc., New York.

Robert Wilson has been elected to the board of directors of The Lincoln Electric Company. Wilson is head of application engineering and director of training. A graduate of Cornell University, he joined Lincoln as field engineer in 1935.

A. F. McDonald has been named manager of a new sales office in Detroit, Michigan, for Reilly Tar and Chemical Corporation. This new office handles the complete line of Reilly products.

M. K. Nolan has been promoted to manager of the Houston office of the J. R. Meek Company, Mid-Continent's representative for the Young Radiator Company. Nolan joined J. R. Meek in 1950. He is a graduate of the South Dakota School of Mines.

Sidney Shuman has been promoted to executive vice president of Fluid Packed Pump Company. Shuman has served in various capacities since joining Fluid Packed Pump Company in 1936.

Robert D. Butler has joined the American Car and Foundry Company, valve division, as sales engineer. He will make his headquarters at Jacksonville, Florida.

Lewis F. Maldeis also has joined the company as sales engineer for ACF valves. He will make his headquarters at Pittsburgh, Pennsylvania.

Frank F. Hohnholt is newly appointed manager of Superior Combustion Industries water-tube steam generator division. He was formerly manager of package generator sales for Foster Wheeler Corporation. Hohnholt has had wide experience in the engineering and sale of packaged boilers.

P. H. Luckett has been named sales manager for Rockwell Manufacturing Company's Macnick (Instrument) division. A graduate of Baylor University, Luckett joined Rockwell in 1948.

Stephen P. Parish, former president of Reed Roller Bit Company has been named chairman of the board. **R. G. Hamaker,** formerly vice president, sales, succeeded Farish as president and **H. C. Tooley,** vice president, manufacturing, was elected executive vice president.

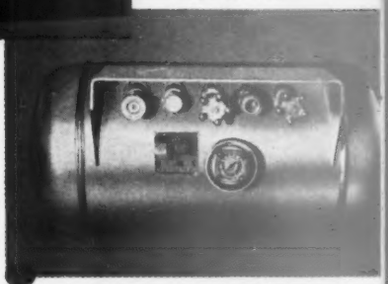
W. B. Noble was designated first vice president in charge of engineering and **E. F. Snow** as second vice president and treasurer.

Lawton L. Laurence has been named manager of engineering, oilfield division, Black, Sivalls & Bryson, Inc. Promotion to the newly-created engineering post places Laurence in charge of a greatly broadened engineering program. Laurence began his career with BS&B in 1941, upon graduation from the University of Oklahoma.

Lee Kelton has been named as manager of oilfield sales, oilfield sales and service division. The appointment places Kelton in charge of field and city sales activities in the 12 BS&B district sales territories covering the oil country. Formerly district sales manager, Casper, Kelton has been with BS&B for 18 years.

L. C. Irvine, general manager of the American Foreign Insurance Association, is visiting South Africa. He intends to visit AFIA South African control office in Johannesburg and branch offices in Durban, Capetown, Port Elizabeth and Bulawayo in Southern Rhodesia.

LPG and
Gasoline
FUEL TANKS



STORAGE TANKS
LPG, Anhydrous Ammonia
and Gasoline

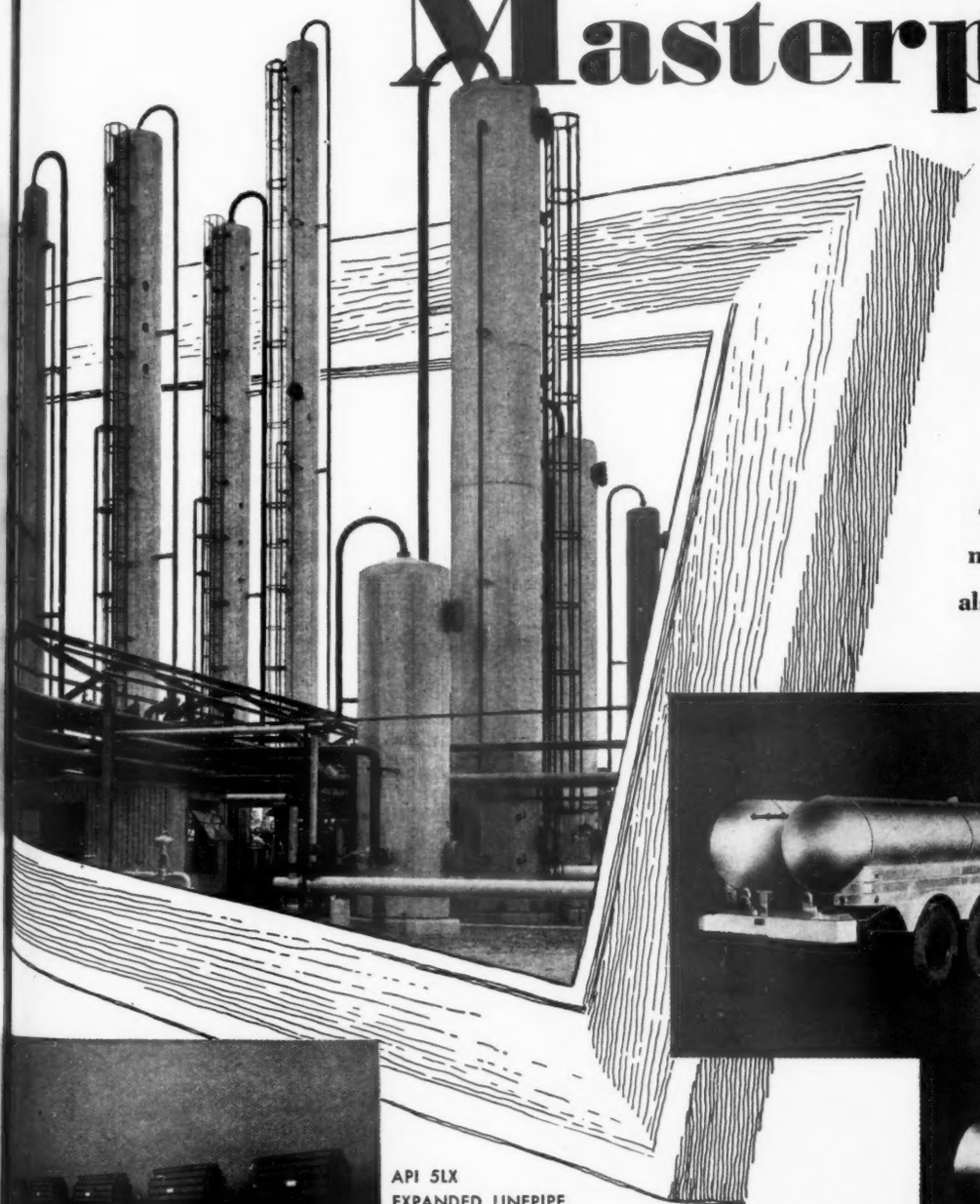
From the Great Southwest . .

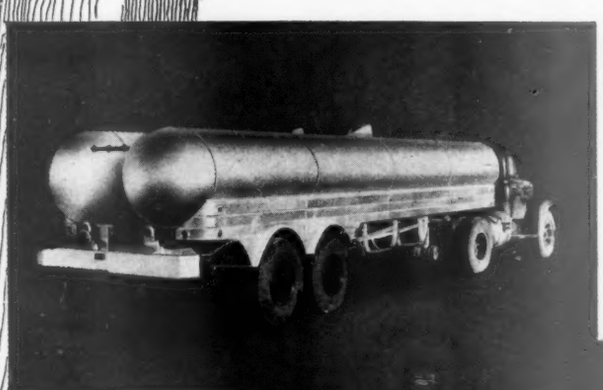
TYPES REFINERY VESSELS

Masterpieces

of steel construction

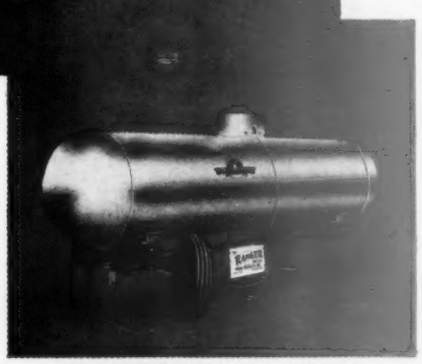
A few examples of production and custom steel fabrication, designed and produced by the facilities of Master Tank & Welding. For any requirements, write, wire or phone. We also warehouse steel plate.





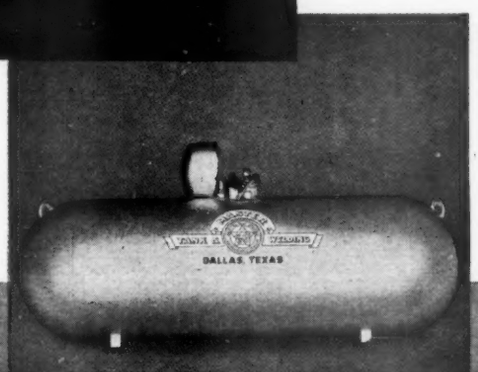
LPG and
Anhydrous
Ammonia
TRANSPORT
TANKS

API 5LX
EXPANDED LINEPIPE
20" - 30" Diameter



ANHYDROUS AMMONIA SYSTEMS

LPG
DOMESTIC
SYSTEMS



MASTER TANK & WELDING

P. O. Box 5146 • Dallas, Texas • PRospect 2441

XUM

GOING FISHING? . . CALL YOUR FRIEND!

ACME

OIL TOOL COMPANY

- Competent Operators
- Rotary Fishing Tool Service
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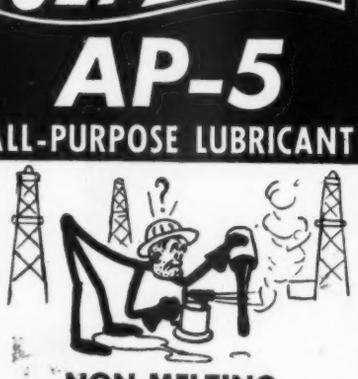
JET-LUBE

AP-5

ALL-PURPOSE LUBRICANT



NON-MELTING

Non-Melting JET-LUBE AP-5 will stay in that hot journal or bearing to get the job done. Contains low friction moly-disulphide. AP-5 reduces bearing temperature. Silica base resists water – won't wash out. Batch controlled. Fully guaranteed.

Order through your supply store or send for complete details

JET-LUBE INC.

7362 W. BEVERLY BLVD., LOS ANGELES 36

N. Sterling, Jr.

▸ **Norman Sterling, Jr.,** has been appointed district manager of Lucey Products Corporation's Rocky Mountain operations. Offices are in the Kittredge Building at Denver. Formerly with Broderick and Bascom Rope and Waukesha Engine and Equipment Company, Sterling attended John Tarleton College.

▸ **S. P. Tschappat,** president of Hercules Tool Company, is on an extensive trip through the California oil fields where he will observe the use of the company's products, and will visit customers and supply companies handling Hercules products. Hercules is celebrating its thirtieth anniversary this year.

▸ **King Boyd** has been named manager of petroleum industry sales for Stewart and Stevenson Services. He will be in charge of oil industry sales and promotion for all Stewart and Stevenson branches throughout Texas. Formerly with General Motors, Boyd is a graduate of Oklahoma University.

▸ **John R. Curran** has been announced director of engineering for Hammel-Dahl Company. A graduate of Northeastern University, Curran joined Hammel-Dahl Company in 1945.

▸ **Bernard Rudner** has joined the research and development staff of The Davison Chemical Corporation. He formerly was employed by General Aniline and Film Corporation. Rudner has a PhD degree from Northwestern University.

▸ **Edward N. Gosselin,** president of Graver Tank and Manufacturing Company, and Phoenix Manufacturing, was featured in a recent issue of the Chicago Daily Tribune. A graduate of Yale University, Gosselin joined Phoenix in 1927, which some years later bought the Graver Company.

▸ **Ben R. Ethridge** has been promoted to assistant chief enginer of Maloney-Crawford Tank and Manufacturing. Ethridge, a graduate of Texas A. and M. will make his headquarters in Tulsa.

▸ **N. W. Richardson** has joined the Geo. P. Reintjes Company. He will be a representative for the Colorado, New Mexico, and West Texas areas.

J. O. Wortham

▸ **J. O. Wortham was** recently appointed sales representative of Willis Oil Tool Company, to service West Texas area and New Mexico. Wortham, formerly with Texas Iron Works, Sargent Engineering, and Dempsey Pumps, is a graduate of Oklahoma U.

▸ **Ken Wernsing** has been named sales and advertising manager for Skookum Company, Inc. He was formerly with Electric Steel Foundry. **Don Koeneke** has been appointed plant superintendent. He has been with the company 15 years.

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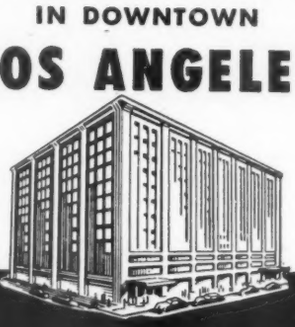

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555 BEAUTIFUL ROOMS
ALL WITH BATH
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- Dining Room
- Cocktail Lounge

One-half block from new Pershing Square Garage

FORCE FEED LUBRICATORS

For operation against discharge pressures of up to 30,000 P.S.I.G.

CHEMICAL FEEDERS

Capacities from .6 pint to 17.5 gallons per hour.

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Manzel

DIVISION OF FRONTIER INDUSTRIES, INC.
291 Babcock St., Buffalo 10, New York

W. A. Johnson, formerly district superintendent of the North Central Texas district, has been appointed assistant manager of Lane-Wells Gulf Coast division. **A. L. Boyd** has been advanced to district superintendent in charge of the North Central Texas district. **W. A. Sherrill** has been transferred to Wichita Falls as assistant district superintendent. **M. C. Young** is new assistant district superintendent of the Ark-La-Tex district. **L. W. Hunt** has been transferred to Longview as subdistrict superintendent of the Ark-La-Tex district. **S. E. Garner** has been named station superintendent at Luling. **J. W. McClure** has been transferred to Synder as district sales engineer.

J. L. Simms is the new sales representative for Oil Center Tool Company's East Texas area. Simms was formerly with National Supply Company before joining Oil Center Tool.

Chester F. Shortal has been named manager of the Kansas City district sales office of J. F. Pritchard and Company of California. Shortal has been with Pritchard since 1951. **W. R. Roeyer** has joined the company as manager of cooling tower and heat exchanger sales.

T. O. McDonald has been appointed sales manager of American Cyanamid Company's refinery chemicals department. He joined Cyanamid in 1945 and in 1950 was named southern district manager for the refinery chemicals department.

Erwin A. Loth was elected to the position of vice president in charge of manufacturing of Pacific Pumps, Inc. Loth, former works manager, has been with Pacific since 1929. **W. E. Brown** has been named Los Angeles district sales manager, centrifugal pump division of Pacific Pumps, Inc. Brown has been a sales engineer with Pacific since 1951. **W. T. Spates** is new sales engineer, centrifugal pump division, in the Los Angeles area. Spates has been with Pacific Pumps since 1929.

H. J. Schlarb has been named special representative in the sales department of Chiksan Company and Chiksan Export Company. He has been with Chiksan Company over nine years.

Robert T. Jones has been appointed western regional sales manager. Jones, formerly sales engineer in the western region, joined Chiksan in 1945. **Bev P. Ragsdale** has been promoted to senior field engineer. Ragsdale has been with Chiksan for nine years and has recently been located in Milwaukee.

W. B. "Bill" Hudson has been appointed district representative in the North Texas area for Alten Foundry and Machine Works. He comes to Alten from the Ideco supply store division of Dresser Industries where he has been serving in an executive sales capacity. He will have headquarters in Wichita Falls.

Hugh Glen has been elected president of Johnston Pump Company succeeding **Mrs. Thomas W. Simmons.** Glen was formerly president of Emsco Derrick and Equipment Company until 1952 when he was elected chairman of the board.

Fritz Richard, vice president of Oil Center Tool Company, and champion golfer in his spare time, almost caused one of the major upsets of the year in amateur golfing circles during the recent Pine Forest Country Club Invitational Meet for top amateur golfers throughout the Southwest.

He took upset wins from a string of four top amateur golfers and reached the finals of the meet. In the final championship rounds, he lost to Jimmy McGonagill of Shreveport.

Charles C. Hornbostel has been appointed administrative assistant to the president of Foster Wheeler Corporation. Hornbostel was previously president of National Company, Inc. He is a graduate of Indiana University, and Harvard Graduate School of Business Administration.

A. L. Peake, Jr., has been appointed assistant sales manager of the southern district, Los Angeles, for Kaiser Steel Corporation. A graduate of Stanford University, Peake joined the company in 1948. **A. G. Grey** has been named assistant sales manager, central district, Oakland. Grey, who joined the company in 1949, is a graduate of Stanford University and Harvard's Graduate School of Business.

W. Harvey Thompson has been named assistant to the executive vice president of H. K. Porter Company, Inc. Before joining Porter, Thompson was vice president of Standard Instrument Corporation and sales manager of the New York District for Diebold, Inc. He succeeds R. F. Allen who was elected a vice president in charge of Buffalo Steel.

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Serving 20 cities in 8 states

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COMFORTABLE GUEST ROOMS — SUPERB CONVENTION FACILITIES — EXCELLENT FOOD — TELEVISION* AND RADIOS — COURTEOUS SERVICE

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New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) THERMOCOUPLE PROTECTOR

A new Conax Thermocouple Speedwell protection tube has been announced by the Conax Corporation.

This tube is said to eliminate junction boxes, prevents "breathing" of corrosive gases or liquids, holds thermocouple in place, and provides interchangeability for checking and replacing thermocouples. The Conax tube is made of stainless steel to resist corrosion.

Circle letter (A) on reply card.

(B) VISCOMETER

The Fann model 35 VG meter was developed by Geophysical Machine Works to fill need for a small, multispeed, laboratory viscometer. Designed for the most exacting research on Newtonian fluids, pseudoplastics, and Bingham bodies, its features make it ideal for rapid determinations of plastic viscosity, yield point, gel strength and for thixotropic studies. It is ruggedly constructed for the hard service usually associated with the testing of muds, slurries, emulsions, etc.

Circle letter (B) on reply card.

(C) DRIVE BELT

A different concept of power transmission, the poly V drive, has just been introduced by the Manhatten Rubber Division of Raybestos-Manhattan, Inc. The poly V belt is a single, endless rubber belt with a series of parallel V ribs molded lengthwise around the inside circumference. The belt is designed to reduce face pressure one half, giving longer life to belt and sheaves.

Circle letter (C) on reply card.

(D) MOLDED INSULATION

Owens-Corning Fiberglas Corporation's newest product in the industrial line is molded pipe-fitting insulation for rapid installation on hot and cold fittings. Made in preformed halves, the insulation is reported light in weight, easy to apply, provides an attractive appearance and has long life. The product is available in sizes to fit American standard cast iron screwed ells, tees, and 45's for pipe sizes from ½ in. to 8 in. pipe and standard butt welded long radius ells and 45's for pipes from 2 in. to 8 in.

Circle letter (D) on reply card.

(E) CIRCUIT BREAKERS

Cutler-Hammer has announced a new line of circuit breaker load centers for positive wiring protection in buildings of all sizes. These unit breakers combine thermal and magnetic trip, quick make and break, trip-free operation, ambient compensation and two position "on-off" lever movement. The unit breaker is calibrated at the factory to insure precision operation and the individual breakers are made tamperproof by factory sealing.

Circle letter (E) on reply card.

(F) GLASS BOARD

Owens-Corning Fiberglas Corporation has announced a incombustible Fiberglas acoustical form board that performs four functions in poured in place gypsum roof decks. It is a barrier to heat and its use greatly increases the insulating value of the deck, resulting in savings on fuel.

Circle letter (F) on reply card.

(G) RADIATION UNITS

American Air Filter Company has added baseboard radiation to its line of Herman Nelson heating and ventilating products. The new units, according to company engineers, were designed for perimeter heating systems, maintaining uniform temperatures from floor to ceiling and to prevent the wall streaking that earlier units caused.

Circle letter (G) on reply card.

(H) VALVE DISPLAY TRUCK

Edward Valves, Inc., subsidiary of Rockwell Manufacturing Company has introduced a new valve display truck, called "The Valvemobile." The Valvemobile features tips on installing, operating, and servicing steel valves. Pictures of typical installations using steel valves, and a color-slide tour of the Edward plant in East Chicago are included.

Circle letter (H) on reply card.

(I) COMPRESSOR PLANT

The J. B. Beaird Company, Inc., has announced a 660 hp packaged compressor plant, said to be the largest ever offered as a complete package. The new packaged plant is designed for single or multiple unit installation on gas pipe lines, gathering lines, and gas lift systems. In spite of its large capacity, the 12SVG packaged compressor plant may be transported on heavy oil field trailers directly to location.

Circle letter (I) on reply card.

(J) SHOVEL LOADERS

The Frank G. Hough Company has recently introduced new models of the "HA" and "HAH" front end shovel loaders with torque converter drive as standard equipment. The "HAH" model is equipped with power steering The "HA" has a pay-load capacity of 16 cu ft and a struck-load capacity of 12 cu ft. The "HAH" has a pay-load capacity of 24 cu ft and a struck-load capacity of 18 cu ft.

Circle letter (J) on reply card.

(K) FITTINGS AND PIPE

Red Jacket Company, Inc., has added to its jacketed equipment a complete new line for use on welding. Fitings are in sizes from 1 to 12 in., in standard weight, extra strong, schedule 160, and double extra strong. Complete line consists of 90 and 45 deg elbows, tees, and crosses.

Circle letter (K) on reply card.

(L) PIPE VISE

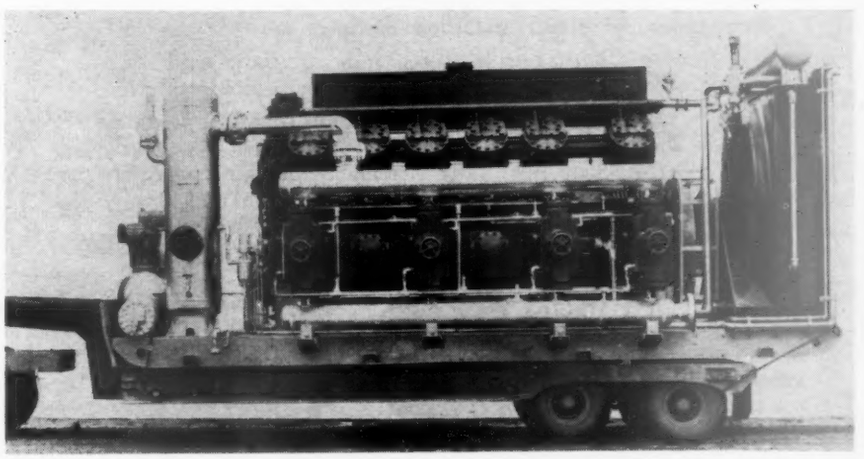
The Ridgid 40A tristand pipe vise, a built-in folding tray that is said to eliminate all loose parts has been announced by The Ridge Tool Company. Equipped with 3 pipe benders, ceiling brace screw, pipe rest and tool hanging slots, the vise is in two models, 40A yoke tristand, ⅛ to 2½ in. capacity and 45A chain vise, ¼ to 4 in.

Circle letter (L) on reply card.

(M) TOOL SETS

J. H. Williams and Company is producing six lathe tool sets that provide for turning, boring, knurling, threading, cutting-off and side work with a minimum number of tools. High speed cutters and wrenches are included in the steel case that is fitted with clips for the holders.

Circle letter (M) on reply card.



J. B. Beaird packaged compressor plant.

XUM

NICHOLSON W. O. TRAPS

Cannot Leak Live Steam

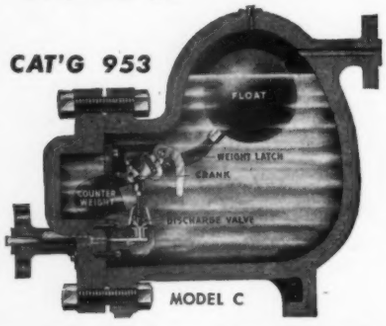
Even though re-evaporation completely dries up its body, a Nicholson weight-operated trap will not leak live steam. Widely used for steam purifiers, super-heated steam lines, headers, separators, heaters, etc.

DRAIN WATER, GASOLINE, OIL

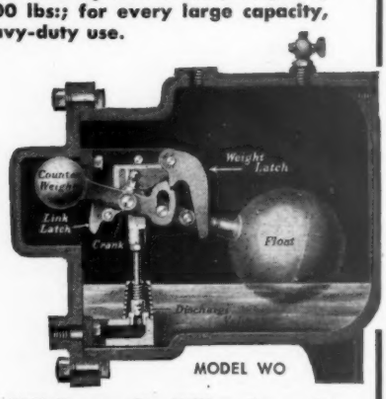
Nicholson W. O. traps also have many applications in natural gas industry: drain gasoline from scrubber head of booster and gas lift compressors; gasoline, oil or moisture from gas well separators, accumulators, after-absorbers, etc.; package natural gasoline plants; gas lines.

4 TYPES—press. to 200, 500, 650, 1500 lbs:; for every large capacity, heavy-duty use.

CAT'G 953



MODEL C

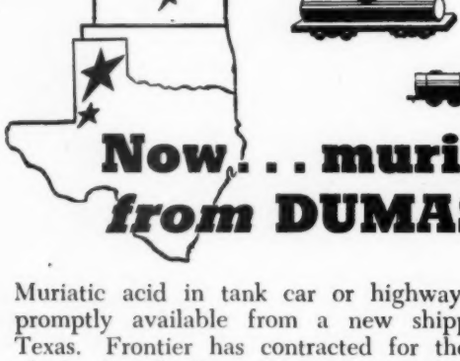


MODEL WO

217 Oregon St., Wilkes-Barre, Pa.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS



Now . . . muriatic acid from DUMAS, TEXAS

Muriatic acid in tank car or highway tanker lots is now promptly available from a new shipping point – Dumas, Texas. Frontier has contracted for the entire HCl output of the Potash Corporation of America plant there – as an additional service to Frontier customers.

Frontier-owned plants and their products are:

Denver City, Texas – caustic soda, muriatic acid, salt
Wichita, Kansas – caustic soda, muriatic acid, chlorine, benzene hexachloride

Speedy shipment over uncongested routes brings dependable "always-as-specified" Frontier chemicals within overnight reach of many users . . . offers transportation and storage savings. Check with us . . . now!

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New Equipment

(N) CLOSING UNIT

The B. M. Davis closing unit uses a mixture of diesel fuel and kerosine, instead of drilling mud, to operate the hydraulic rams of the blowout preventor. This eliminates the sanding-up of the rams, cylinders, and lines. The entire unit is skid-mounted and has a 50-gal tank for storage. Under normal operating conditions, it will close the rams in less than one minute.

Circle letter (N) on reply card.

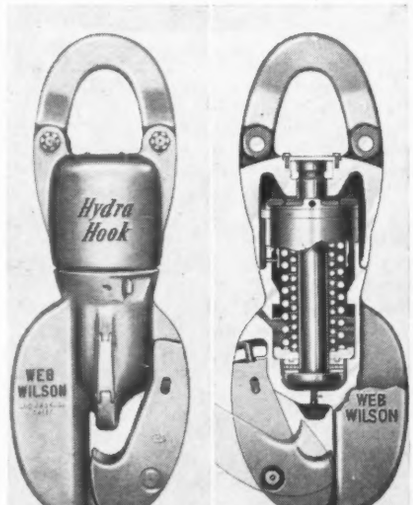
(O) MOTORS

U. S. Electrical Motors, Inc., have increased to 150 hp their horizontal totally-enclosed and explosion proof motors. The motors are designed for protection against dirt, moisture, oil and chemicals. The explosion-proof motors, Type SE, are designed for service where inflammable gases, volatile liquids or combustible dusts may be present. Both type motors are double-enclosed with a built-in fan for full ventilation and greater heat dissipation.

Circle letter (O) on reply card.

(P) HYDRA HOOKS

Web Wilson Oil Tools, Inc. claim many modern features are embodied in the new line of Hydra Hooks for rotary drilling, and for handling casing and tubing. The main bearing, springs, and the plunger operate in an oil-bath to provide a "dash pot" action that ensures perfect, permanent lubrication. This "oil cushion" provides a controlled hydraulic spring action that eliminates "bouncing" the tool joint in the box.



Circle letter (P) on reply card.

(Q) VALVE OPERATORS

McBain Corporation, subsidiary of Harvill Corporation, has released information on its Tork-Master electric valve operators, which are designed for operation of all types of conventional gate, globe, plug, butterfly, and other valves in sizes from two and one-half inches upward. Basic design provides for a wide range of operating speeds, output torque, and length of travel to accommodate various valve designs and operating conditions. Mounting feature provides for installation on valves in or out of service without alteration of the valve.

Circle letter (Q) on reply card.

(R) PACKAGED FITTING

The Watson-Stillman Fittings Division of H. K. Porter Company, Inc., is packaging forged steel fittings in cardboard cartons to protect external threads from damage during shipment or in storage. Parts to be packaged include hex head plugs and bushings, square head plugs and round head plugs in sizes ⅛ to 2 in.

Besides assuring complete protection of external threads the handy cartons are also ideal for stocking. They can be stacked neatly in storage bins with labels facing outward for quick and positive identification. The label clearly designates the name of the part, the size, material and quantity.

Circle letter (R) on reply card.

(S) DRILLING FLUID

Superior Mix, developed by Oil Base, Inc., is an oil base drilling fluid designed for use under high pressures and temperatures. It is particularly suited for drilling and completion operations in deep, hot holes and for drilling through heaving shales and other troublesome formations. Super Mix is also being used as a packer fluid as it does not settle, disintegrate, solidify, or deteriorate by standing idle for long periods of time and can be used as a workover fluid when the packer is pulled. When used as a perforating fluid, Super Mix withstands the excessive heat and force of the charge and does not bake into a hard plug to seal off the newly shot holes.

Circle letter (S) on reply card.

(T) ROLLER BEARING

Rollway Bearing Company, Inc., has collaborated with Denison Engineering Company in the design of a special cylindrical roller bearing. The bearing is an MCS-31870 that is but one of a series of sizes being currently made. It consists of a separable cylindrical outer race and a channel type inner race, using crowned rollers held in place and guided by a bronze retainer.

Circle letter (T) on reply card.

(U) WIRE ROPE PRESSING

A pressing system, announced by Jones and Laughlin Steel Corporation, employs an aluminum alloy clamp or sleeve that is squeezed around wire rope in a special 300 ton hydraulic press. Called Ja1Klamp, the device is used as a mechanical method of splicing eyes, with or without thimbles, in the ends of wire rope. Using this system a worker can make as many as 20 or 30 splices in an hour, as compared to 6 or 7 using hand methods.

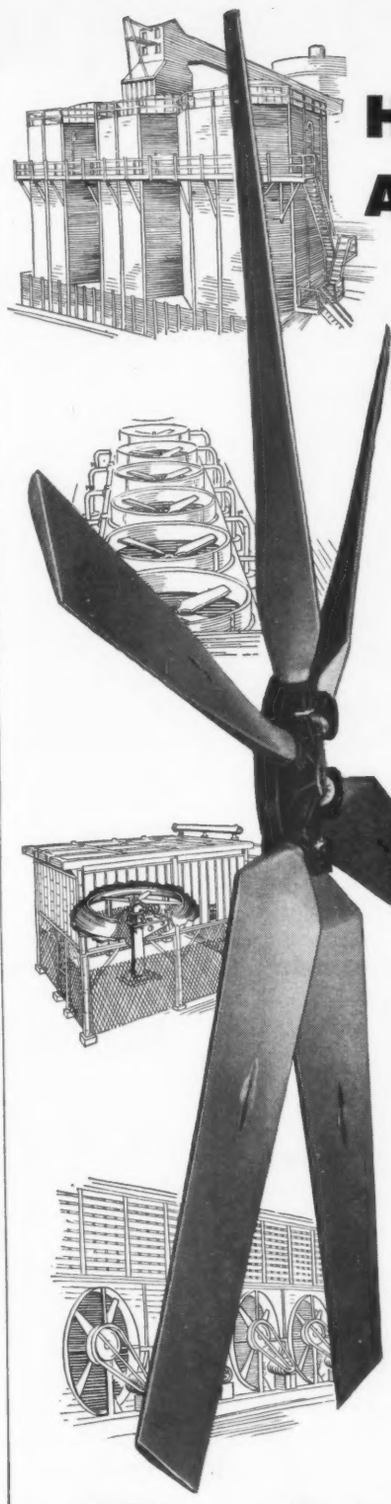
Circle letter (U) on reply card.

(V) VOLUME PUMP

A new, motor-driven controlled volume pump for use in proportional feed systems has been announced by the Milton Roy Company. A mechanical, single revolution clutch arrangement permits one stroke of the pump in response to an electrical signal to effect feed of an additive in proportion to main line flow rate. This signal may be transmitted by a timer or electrical contacts on a positive displacement meter. These pumps have capacities from one pint to 1350 gal per hour, against discharge pressures up to 50,000 psi.

In one installation, an explosion-proof positive displacement meter in a gasoline pipe line is equipped with an electrical contactor.

Circle letter (V) on reply card.



Here's Why Aeromaster Fans mean more satisfactory cooling equipment operation

Manufacturers and users of cooling equipment agree... Aeromaster Fans give outstanding service. Here are the reasons why.

Aeromaster Fans are *precision engineered,* adapted from high speed aircraft propellers. They have adjustable blade pitch and anti-flutter design . . . therefore, require less horsepower. And they last longer too, thanks to the exclusive Aeroloid blade coating to resist acids and alkalies, abrasion and weather. Overall result: Aeromaster Fans *give more cooling at lower cost.*

Available in 4, 6, or 8 blade styles, in diameters of 5 to 24 ft., with capacities up to 1,000,000 cubic feet per minute, all Aeromaster Fans are fully guaranteed.

Koppers also has trained engineering specialists available in principal cities, insuring prompt, expert Aeromaster Fan service. And Koppers is always ready to consult with you on special fan problems. Next time you plan a replacement of present fans, specify Aeromaster. And when you consider new equipment, call on Koppers . . . always eager to be of service.

KOPPERS

Aeromaster Fans

METAL PRODUCTS DIV. • KOPPERS COMPANY, INC. • BALTIMORE, MD. • This Koppers Division also supplies industry with Fast's Couplings, American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators and Gas Apparatus. *Engineered* Products Sold with *Service*

MAIL COUPON TODAY FOR COMPLETE INFORMATION

KOPPERS COMPANY, INC., *Aeromaster Fans,* 226 Scott St., Baltimore 3, Md.
Gentlemen: Please send me detailed information on Aeromaster Fans for

(name and type of equipment to be cooled)

Name

Title Company

Address

City Zone State

XUM

(W) SILICONE FLUID

Dow Corning Corporation has developed a new silicone fluid that is said to be compatible with organic materials. Called Dow Corning 555 fluid, it is water white, odorless, and easily diluted with such materials as lanolin, beeswax, mineral oil and 95 per cent ethanol. It shows promise as a release agent for specialized applications, as an additive for petroleum products, etc.

Circle letter (W) on reply card.

(X) SAFETY DEVICE

Kwik-Mix Company has announced a new safety attachment that is optional on all S10 type Moto-Bug. The attachment is a heavy gage steel upright post ending in a broad curved steel plate. It not only protects the operator from a sudden jolt but will help reduce fatigue.

Circle letter (X) on reply card.

(Y) MOBILE RADIOS

Two complete mobile radio systems, which are particularly applicable for use by the petroleum industry, has been developed by Mobile Communications Department of Allen B. Du Pont Laboratories, Inc.

The units are designed to operate in the 25-54 megacycle and ultra-high frequency 450-470 megacycle bands.

Circle letter (Y) on reply card.

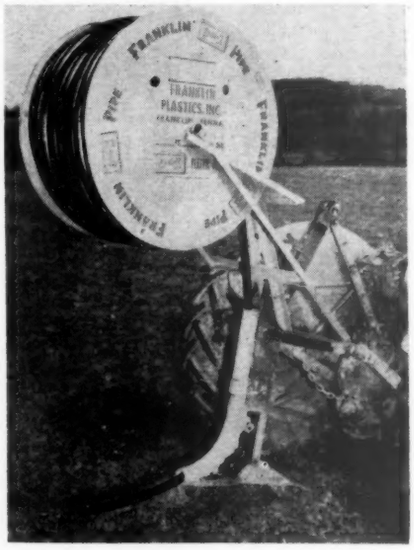
(Z) RADIOS

General Electric has announced new radio transmitter-receiver combination units for operation at recently authorized frequencies between 450 and 470 megacycles. The new radios are expected to be useful in city police and fire departments, taxicabs, and some industrial applications. Mobile models will function from either six or 12-volt batteries.

Circle letter (Z) on reply card.

(AA) PLASTIC PIPE LAYER

Franklin Plastics, Inc., has designed a new implement for the effortless laying of plastic pipe, the Franklin Plastic Pipe



Layer. Operating at tractor speeds, the amazing device will uncover a trench, lay in the pipe 14 to 20 in. deep, and back fill — all in one continuous operation. At a recent demonstration, 1000 feet was installed in less than 10 minutes.

Circle letter (AA) on reply card.

(AB) COMPRESSORS

Le Roi Company has introduced a new 600 CTM (compressor tractor mounted), which will bring compressed air power to the more remote areas. The 600 CTM with side booms and twin wagon drill air feed asemblies of the Le Roi-Cleveland SB30 or PL30 class, can convert retired tractors into fast moving integral drilling units. This compressor can be readily mounted on two leading makes of crawler tractors.

Circle letter (AB) on reply card.

(AC) CEMENTED CARBIDE

Carboloy Department of General Electric Company has announced a new medium duty, high wear resistant steel cutting grade cemented carbide for light roughing and general finishing. Developed to be ahead of the trend toward faster machining speeds in the light roughing and general finishing field, the new grade 350 cemented carbide is considerably tougher than present carbides.

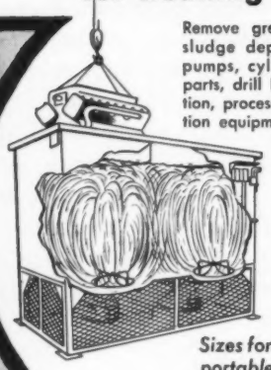
Circle letter (AC) on reply card

(AD) WASHER, "O" RING

A one-piece washer and rubber "O" ring combination, the "O" ring permanently bonded to the washer, has been developed by Rubber Teck, Incorporated, Los Angeles. Called "Duo-Seals," the units are available in three-sixteenths to five-eighths in nominal bolt diameter. They provide leak proof sealing against fluids, gases or air around bolts where they go through walls, bulkheads or skins retaining such fluids or gases. Duo-Seals are color-coded according to use, for fuel, general purpose, high temperature or oil.

Circle letter (AD) on reply card.

NEW! TURBO BLAST
CLEANING MACHINES
cut cleaning time in half!



Remove grease, oil, wax and sludge deposits from valves, pumps, cylinder blocks engine parts, drill bits and all production, processing and transportation equipment in a fraction of time required by soak methods. Impellers create a vigorous scrubbing action. Solution is heated with steam, fuel oil, natural or manufactured gas . . . thermostat control for efficiency and economy. Turbo-Blast cleans thoroughly . . . including recessed areas . . . eliminates hand-brushing. Performance facts available.

Sizes for all requirements from small portable units to specially designed systems of any size, conveyorized or batch types.

STORM-VULCAN, INC.
2225 BURBANK DALLAS, TEXAS

PROVED BY PERFORMANCE
Write for Catalog

Storm-Vulcan, Inc.,
2225 Burbank St., Dallas, Texas
Send me Turbo-Blast Catalog.
Name_____
Company_____
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If you are moving or expect possibly to move any time soon, save the coupon below for your convenient change of address. It will prevent your copy of The Petroleum Engineer from being lost or misdirected.

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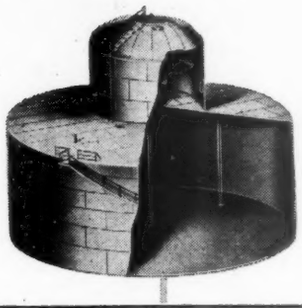
P. O. Box 1589 • Dallas
CHANGE MY ADDRESS, beginning with the_____issue

FROM:_____

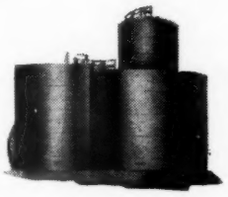
TO:_____

the HAMMOND DIALIFT*

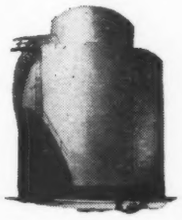
MONEY SAVER FOR PRODUCT-STORAGE OPERATORS!



The Hammond DIALIFT is the modern tank for eliminating breathing losses and reducing filling losses. It gives maximum conservation of vapors at lowest cost.

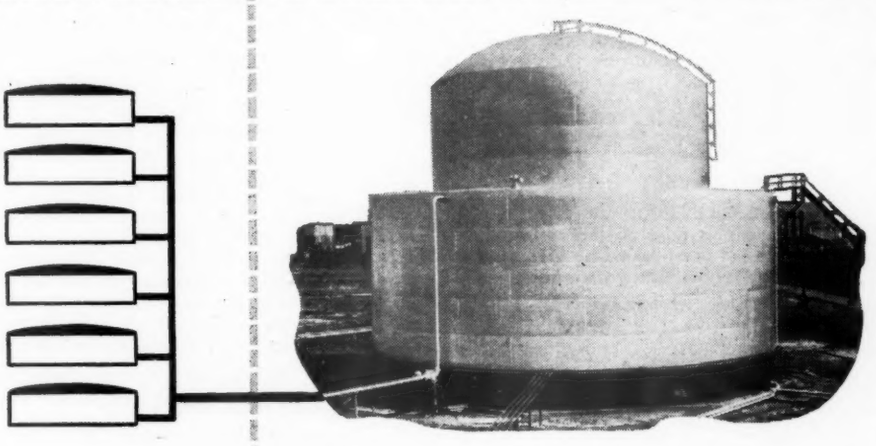


42'6" x 40' Liquid Storage Tank
22' x 17'9" Dialift. Housing — 6500 cu. ft. capacity Inter connected to a 25' x 40' Cone Roof Tank



50' x 48' Liquid Storage Tank
30' x 15'9" Dialift. Housing — 12,500 cu. ft. capacity

The DIALIFT consists of a tubular membrane attached gas-tight to the inside periphery of a cylindrical housing. In operation the DIALIFT functions as the lung of the storage tank. The membrane lifts under a slight pressure when additional vapor storage space is needed, and lowers when less vapor space is required; self-adjusting to the constantly changing breathing conditions within the tank.



80' x 30' Liquid Storage Tank
35' x 17'9" Dialift. Housing — 20,000 cu. ft. capacity

It is easy to convert an existing Cone Roof Tank to an efficient DIALIFT installation. A DIALIFT housing is superimposed on the existing roof, breather holes are installed through the roof plating permitting a free passage for all vapors, no other preparation is necessary.

60' x 48' Ground Type Dialift.
150,000 cu. ft. capacity

*patented

Bulletin 53DL details and describes the Hammond Dialift . . . *Write for your copy.*

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Trade Literature

Publication will be sent free.

(AE) PIPE LINE FELT

Transhield, a new lightweight, economical, reinforced asbestos pipe line felt, is the subject of an illustrated 4-page folder issued by Johns-Manville. Easy to apply at high speeds, Transhield is recommended as a standard protective coating for pipe enamel and to offset problems caused by expansion and contraction of heavy clay soils.

Circle letter (AE) on reply card.

(AF) TAPE RECORDING

A new type of magnetic tape recording is the subject of a new bulletin issued by Ampex Corporation. By using various filters and mixes interference can be eliminated and interpretation of disputable areas can be clarified. Designed for use in the field, the magnetic tape seismic drum recorder Model 700 is easy to operate and maintain and has safety features to protect records.

Circle letter (AF) on reply card.

(AG) ZINC ANODES

American Zinc Institute, Inc., has published a folder on galvanic anodes for cathodic protection and grounding. Sizes, shapes, and dimensions along with the uses are illustrated.

Circle letter (AG) on reply card.

(AH) WIRE LINE STRIPPER

A new wire line stripper is the subject of a folder released by Regan Forge and Engineering. Controlled pressure is used to maintain a constant contact thus insuring an orderly and clean wiping job. Safety factors are increased also due to the automatic action of the stripper.

Circle letter (AH) on reply card.

(AI) COOLING TOWERS

A new folder illustrating its Twin Flow cooling towers has been released by The Marley Company. Designed to provide large amounts of cold water, Twin Flows utilize more than 100 levels of filling deck, giving prolonged air-water contact.

Circle letter (AI) on reply card.

(AJ) LOST CIRCULATION

Palco Seal, a fibrous redwood product specially processed to prevent loss of circulation in drilling muds, is described in a new bulletin just released by The Pacific Lumber Company. The material is available in 40 lb bags as well as in 80 lb bales. Graphs showing comparative sealing efficiency test data procured under rigidly controlled conditions are contained in the bulletin.

Circle letter (AJ) on reply card.

(AK) FILMS

Industrial motion pictures, sponsored and distributed by United States Steel, is the subject of a 1954 catalog that has been released by the company. The films are available on a free loan basis for showing to all recognized groups.

Circle letter (AK) on reply card.

(AL) TRUCKS

A booklet showing how Autocar trucks are built and pointing up their features, has just been released by the Autocar division of The White Motor Company. The 20 page booklet is a graphic description that highlights Autocar's construction advantages.

Circle letter (AL) on reply card.

(AM) BACKFILLER

The new Cleveland Model 190 backfiller, is the subject of a 6 page, 2 color bulletin recently published by The Cleveland Trencher Company. Outstanding features of the backfiller are effectively presented with each feature pointed out and placed on a large scale photograph of Model 190. Complete dimensional drawings and specifications of the Model 190 are given on the back cover.

Circle letter (AM) on reply card.

(AN) WIRE MESH DEMISTERS

Otto H. York Company, Inc., has made available a detailed case study of how the installation of a stainless steel wire mesh demister pad in a vacuum tower resulted in a 90 per cent reduction in catalyst poisoning, at the General Petroleum Corporation's Torrence refinery. Also included is a detailed description of tower operating conditions, the method of wire-mesh installation and a table comparing metals content before and after the installation was made.

Circle letter (AN) on reply card.

(AO) V-BELT DATA

A detailed brochure containing engineering and design data on multiple v-belts has just been issued by the Goodyear Tire and Rubber Company. Containing 15 sections, the handbook gives a comprehensive explanation of the fundamentals of v-belt design as well as a section on Goodyear's line of steel cable v-belts.

Circle letter (AO) on reply card.

(AP) PIPE WRAP

Publication of a new four-page brochure on Blue Flag glass fiber underground pipe wrap has been published by Glass Fibers, Inc. The folder describes the function of the bonded mat material in reinforcing enamel coatings which are applied to underground oil and gas transmission lines to prevent corrosion. Brochure contains test data on penetration ratios for reinforced and unreinforced enamels.

Circle letter (AP) on reply card.

(AQ) PUMPS

Laboratory and pilot plant controlled volume pumps are the subject of technical papers 58 and 59, released by Milton Roy Company. Minipump Constametric® is recommended for micro-studies involving mixing and blending of fluids in small diameter tubing (No. 59). Titronic® controlled volume pump is used for automatic concentration control where there is relatively little change in conductivity, pH, specific gravity or other variable between desired control limits. (No. 58). Minipump,® for controlling flows as low as three milliliters per hour, is used in reaction kinetics studies of continuous processes.

Circle letter (AQ) on reply card.

(AR) PLASTIC PACKING

A new release by Durametallic Corporation is its Dura plastic teflon packing bulletin. Resistant to heat and operating inert to most fluids, teflon packing provides long uninterrupted sealing from minus 90 F to 450 F. It is supplied in die-mold ring and spiral form, ¼-in. and larger.

Circle letter (AR) on reply card.

(AS) SPRAY, SUCTION HOSE

A specific hose for each type of spraying job is the subject in Quaker Rubber Corporation's spray hose bulletin. Another bulletin describes 11 widely different types of suction hose to fill every industrial need. Descriptive data include construction, sizes, weights, working pressures, and recommended uses of the two hoses. Types of couplings also are specified.

Circle letter (AS) on reply card.

(AT) HEATERS, SEPARATORS

Black, Sivalls & Bryson, Inc., has published new catalogs on indirect heaters and high pressure horizontal separators. Catalog 32-02, 16 pages, gives complete information on the new model series 70 indirect heater, including capacities, dimensions flow coil sizes, and standard equipment on a newly expanded line. Catalog 30-10, 8 pages, describes the complete line of model HLC separators, and also lists capacities, specifications, and dimensions of the 27 available sizes.

Circle letter (AT) on reply card.

(AU) FORM BOARD

A four page publication describing and illustrating Fiberglas acoustical form board for poured in place roof decks for industrial plants, commercial buildings, and schools has been released by Owens-Corning Fiberglas Corporation. Information is included about Owens-Corning's two types of incombustible form boards. One has a bonded Fiberglas mat facing to provide a uniform, more attractive appearance as an interior ceiling and the other is sanded on one side for use when a smooth ceiling surface is desired.

Circle letter (AU) on reply card.

(AV) MOTORPUMP

A booklet, dealing with the selection of the proper motorpump for any specific job, has been published by Ingersoll-Rand Company. A slide film presentation in printed form, the booklet gives a brief description of what a centrifugal pump is and how it works.

Circle letter (AV) on reply card.

(AW) PIPING, TUBING

Michigan Pipe Company has recently published two circulars describing its products. Fabricated piping, tubing, and fittings, made of different grades of steel, are featured in one circular. Corrosion resistant pipe for industrial piping is the subject of the other.

Circle letter (AW) on reply card.

(AX) CASING HANGERS, WELL HEADS

McEvoy Company has announced a new catalog that is available for distribution. A new line of improved casing hangers and well heads, type "S", is fully described. Catalog No. 54 contains an up-to-date listing, including the automatic self-sealing conduit gate valves, gas lifts, well head equipment. Also available for distribution is Bulletin No. 101.

Circle letter (AX) on reply card.

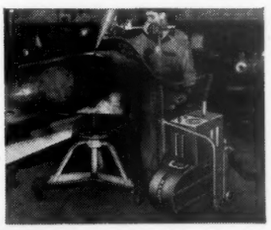
Higher current density with Manual Lincolnweld permits 100% butt welds in ¾" plate with single pass each side.

ELIMINATES JOINT PREPARATION SPEEDS WELDING to cut your costs

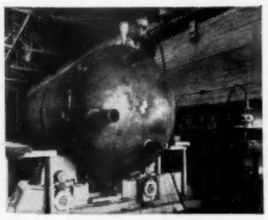
STRONGER, dependable welds of X-ray quality are produced in less time with Manual Lincolnweld's hidden arc welding in granular flux. As a result, countless fabricating, maintenance and construction jobs can be done for less cost than by conventional hand welding with coated electrodes.

Costs of joint preparation can now be eliminated on plates up to ¾" thickness. With a Current Control dial setting of 500 for 5/64" diameter electrodes, 100% penetration can be achieved on plate as thick as ¾" with single pass welds from each side.

In operation, a continuous wire electrode is fed automatically to the joint beneath a layer of granular flux. Discomfort of smoke and arc rays is eliminated.



Mounted *on simple fixture, Manual Lincolnweld completes pressure-tight joint on 12" alloy steel fitting in only 1½ minutes.*



Fabricates *pressure vessel with Manual Lincolnweld. Welding gun is hand held. Tank rotates on power rolls.*

Send for Cost Cutting Facts—Speeds and procedures for welding with Manual Lincolnweld are in Bulletin 1303. Available by writing on your letterhead.

THE LINCOLN ELECTRIC COMPANY
Dept. 2804, Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

(AY) INSTRUMENT PIPING

"Valves for instrument piping and general use," is subject of new bulletin by Jerguson Gage and Valve Company. New Data Unit 234 gives features, application information, and specifications. This four-page Data Unit contains illustrations and drawings showing how these valves combine unions, nipples, reducers, elbows, etc. into one unit.

Circle letter (AY) on reply card.

(AZ) TURBINE GENERATOR

Geared turbine generators, 200 kw to 1500 kw, for both a-c and d-c service are the subject of Bulletin 1969 now offered by Worthington Corporation. The bulletin describes engineering and construction features of the turbine generators, including two types of governing arrangements, hand and automatic nozzle controls, and other controls and accessories.

Circle letter (AZ) on reply card.

(BA) RODLESS PUMP

Sargent Engineering Corporation has released information on its rodless pumps with some experience figures in different fields. The pump consists essentially of a standard production pump coupled to and driven by a hydraulic engine valve. Sargent and rodless pumps are adaptable to whipstocked or extremely crooked holes.

Circle letter (BA) on reply card.

(BB) FLOW METERS

Minneapolis-Honeywell has released catalog 2320 that describes all types of flow meters made by its industrial division. It includes indicating, recording, integrating, and controlling instruments of both evenly graduated and square root types, as well as area meters and differential converters. A section is included on flow approximations and installation information.

Circle letter (BB) on reply card.

(BC) SERVICES, PRODUCTS

An attractive brochure has been published on its services and products by General American Transportation Corporation. Through illustration and pictures General American shows how it services industry. The hard-back booklet contains 47 pages, and is thoroughly illustrated.

Circle letter (BC) on reply card.

(BD) FITTINGS CATALOG

Ladish Company has published a completely illustrated, two-color, 304-page catalog, titled Ladish Fittings Catalog No. 55. The catalog contains detailed specifications on complete fittings line, plus useful technical data. Major sections include 68 pages on butt welding fittings, and other pages are devoted to: Forged steel ASA flanges, large od and TEMA flanges, long welding neck flanges, forged weldless rolled rings, forged steel fittings, stainless and alloy fittings, and technical data to simplify piping design problems.

Circle letter (BD) on reply card.

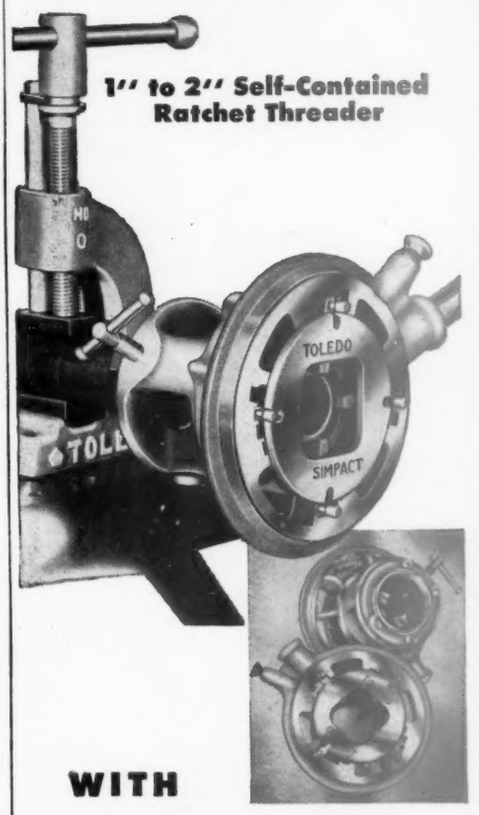
(BE) CHART

Lebanon Steel Foundry has made available a slide chart containing analyses, designations, mechanical properties, and heat treatments of its products. Covered are 19 Lebanon carbon and low allow grades and 17 stainless and corrosion resistant grades. The 9½ by 4-in. chart is constructed of paper and is easily read.

Circle letter (BE) on reply card.

NEW
Improved
TOLEDO
Simpact

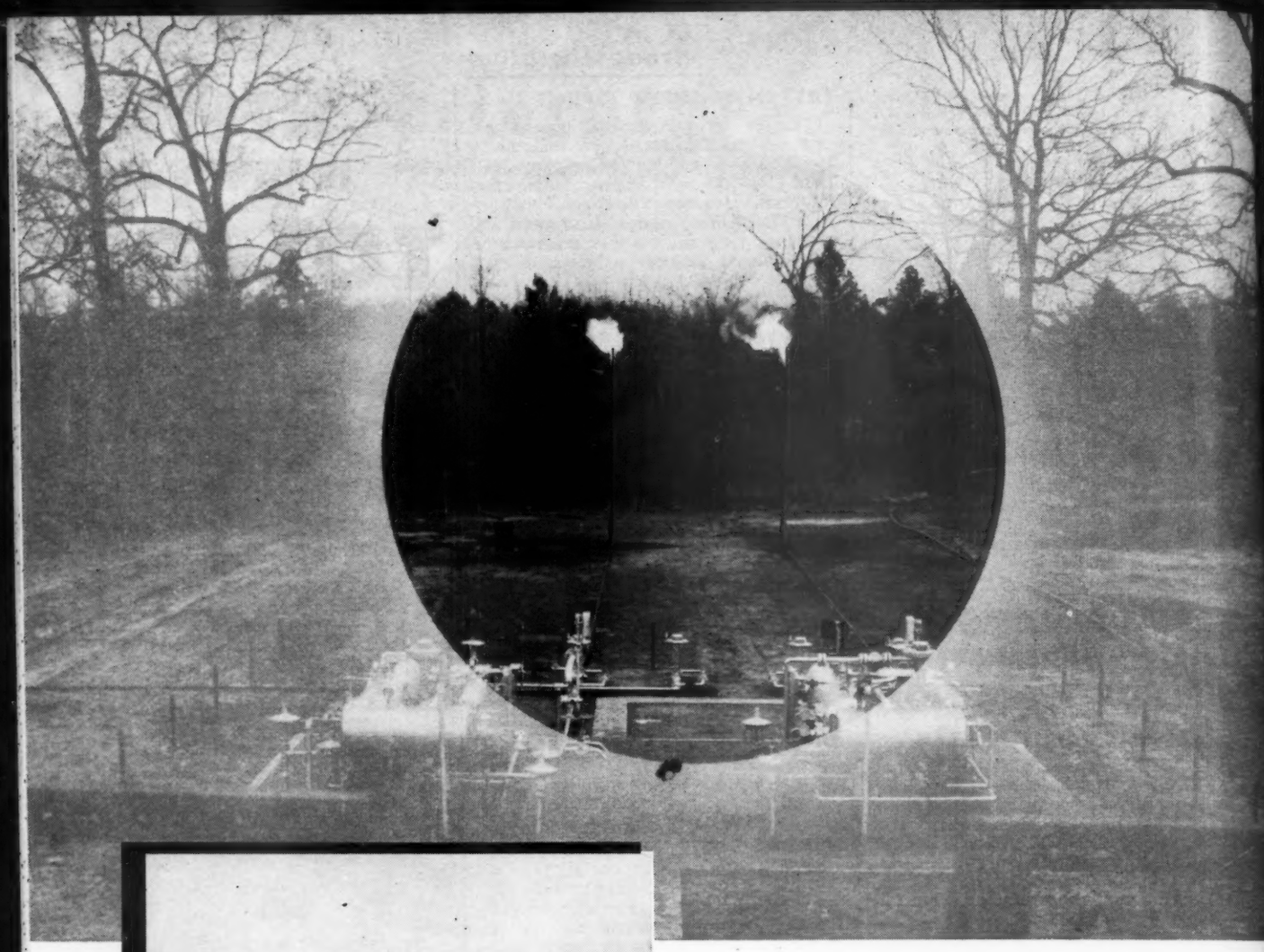
1" to 2" Self-Contained Ratchet Threader

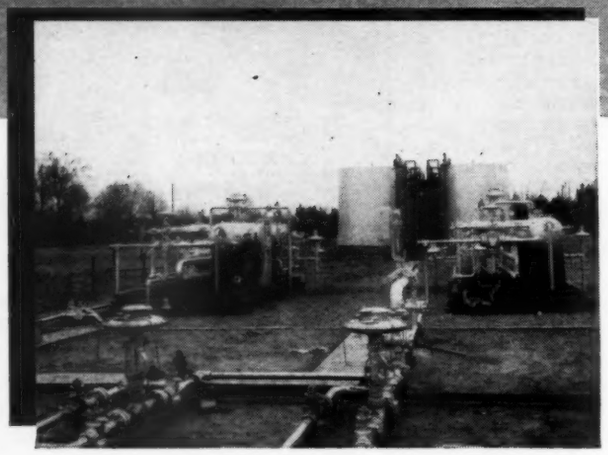


WITH
CAM-TYPE
PIPE HOLDER

★ *Improved* cam-type quick-action pipe holder has broader jaws for more positive grip on pipe.
★ Free action cam assures instant setting to any size—1" to 2".
★ Easy to center . . . you get perfect aligned threads.
★ Fewer moving parts . . . minimum wear . . . light in weight. Amazingly compact . . . will thread a pipe projecting through a wall as short as 6¼".
★ Accuracy proven through the years . . . dies recede along tapered steps. A fine quality tool—yet low in cost! Write for new catalog. Order through your supply house. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.

RELY ON THE LEADER!
TOLEDO
PIPE TOOLS..POWER PIPE MACHINES..POWER DRIVES





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(RESERVOIR DOLLAR)
WASTE IS HELD TO THE MINIMUM WITH

National "LTX" Systems

Heat in base of "LTX" Separator gives advantages NOT obtained by use of "LTG" (Low Temperature Glycol) Separator with no heat in base.

1. LTX means maximum high pressure gas sale, minimum low pressure gas waste, and maximum stock tank liquid recovery per unit volume of well effluent produced.
2. LTX means ability to operate without glycol injection.
3. LTX means ability to operate with glycol injection at minimum cost.
4. LTX means proven maximum trouble-free operation for all conditions and locations.

*T. M. Reg. U. S. Pat. Off.

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